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SYSTEM

OF

SURGERY.

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Vol. II.

MINOR, PLASTIC, AND MILITARY SURGERY—DISEASES OF THE BONES—ORTHOPÆDIC SURGERY—ANEURYSM—SURGERY OF THE ARTERIES, VEINS AND LYMPHATICS—DISEASES AND INJURIES OF THE HEAD—SURGERY OF THE SPINE—SURGERY OF THE NERVES.

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CONTENTS OF VOLUME II.

MINOR SURGERY.

By HENRY R. WHARTON, M. D.

Bandages.

Bandages constitute one of the most widely used and important surgical dressings: they are very generally employed to hold dressings in contact with wounds, to make pressure, and to secure splints in place in the treatment of fractures and dislocations. Bandages may be prepared of various materials, such as muslin (bleached or unbleached), linen, crinoline, flannel, cheese- or tobacco-cloth, rubber sheeting; and of these the most widely used is the bandage made from unbleached muslin, because of its cheapness. Flannel, from its elasticity, is sometimes used, but its employment for bandages is now generally limited to its use in dressings after operative work upon the eye and for the primary roller in the application of plaster-of-Paris dressings.

Bandages are either *simple*, when composed of one piece of material, such as the ordinary roller bandage, or *compound*, when prepared of one or more pieces secured together and adapted by size and shape to peculiar objects. Every practitioner should be perfectly familiar with the general rules of bandaging, and proficient in the application of the roller bandage, for a well-applied bandage adds much to the comfort of the patient, and the method of its application often secures for the physician the confidence both of the patient and his friends, while, on the other hand, a badly-applied bandage is apt to be uncomfortable and insecure.

The Roller Bandage.—The roller bandage consists of a strip of some one of the materials previously mentioned, of variable length and width, which, for ease of application, is rolled into a cylindrical form. A bandage rolled into the form of a cylinder is called a single or single-headed roller; if rolled from each extremity toward the centre, so that two cylinders are formed, joined by a central strip, a double or double-headed roller is formed. Double rollers are not much used at the present time, and in practice the single roller will be found to be amply sufficient for the application of almost all the bandages employed in surgical dressings. The free end of the roller bandage is called the *initial extremity;* the end which is enclosed in the centre of the cylinder is the *terminal extremity;* and the portion between the extremities, *the body*. The roller bandage has two surfaces, *external* and *internal*. The material commonly employed for the roller bandage is unbleached muslin, although for special purposes linen, flannel, rubber sheeting, crinoline, or cheese-cloth may be used. It is important that the roller bandage should consist of one piece, free from seams or selvage, for if made from a number of pieces sewed together, or if it contains creases

or selvage, it cannot be so neatly applied and it is not so comfortable to the patient, as it is apt to leave creases upon the skin. In preparing the ordinary muslin bandage the material is torn into strips varying in length and width according to the portion of the body to which it is to be applied, and it is then rolled into a cylinder, either by hand or by a machine constructed for the purpose.

Every practitioner should be able to roll a bandage by hand, for in practice the medical attendant may at any moment be called upon to roll a bandage in order to apply dressing, and the art is acquired by a little practice. To roll a bandage by hand the strip should be folded at one extremity several times until a small cylinder is formed; this is then grasped by its extremities by the thumb and index finger of the left hand; the free extremity of the strip is then grasped by the thumb and index finger of the right hand, and by alternating pronation and supination of the right hand the cylinder is revolved and the roller is formed: the firmness of the roller will depend upon the amount of tension which is kept upon the free extremity of the strip during the revolution of the cylinder (Fig. 1).

Fig. 1.

Rolling a bandage by hand.

Dimensions of Bandages.

Bandages vary in length and width according to the purposes for which they are employed, and in practice it will be found that a small variety of bandages will be amply sufficient for the application of all the ordinary surgical dressings. The following list comprises those most frequently used, and shows their dimensions:

Bandage one inch in width, three yards in length, for bandage for hand, fingers, and toes.

Bandage two inches wide, six yards in length, for head bandages and for the extremities in children.

Bandage two and a half inches wide, seven yards in length, for bandages of the extremities in adults; a roller of this size is the one most generally used.

Bandage three inches wide, nine yards in length, for bandages of the thigh, groin, and trunk.

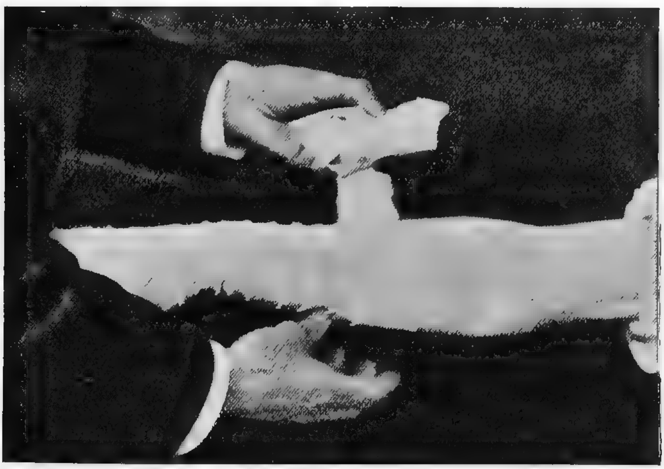
Bandage four inches wide, ten yards in length, for bandages of the trunk.

General Rules for Bandaging.

In applying a roller bandage the operator should place the external surface of the free extremity of the roller on the part, and hold it in position with the fingers of the left hand until fixed by a few turns of the roller, the cylinder being held in the right hand, so that, as the

bandage is unwound it rolls in the operator's hand, thereby giving him more control of it; care should also be taken that the turns are applied smoothly to the surface and that the pressure exerted by each turn is uniform. When a bandage is applied to a limb the surgeon should see that the limb is in the position that it should occupy, as regards flexion and extension, when the dressing is completed, for a bandage applied when the limb is flexed will exert too much pressure when the limb is extended, and may thus become a matter of discomfort or even of danger to the patient, or if applied to an extended limb it will become uncomfortable upon flexion. Those who have little experience in the application of roller bandages are apt to apply their bandages too tightly, and this may lead to disastrous consequences, especially in the dressing of fractures. When the bandage has been completed the terminal extremity should be secured by a pin or safety-pin applied transversely to the bandage, and if a pin be used its point should be buried in the folds of the bandage; or if the bandage be a narrow one the end may be split, and the two tails resulting may be secured around the part by tying. In removing a bandage the folds should be carefully gathered up into a loose mass as the bandage is unwound, the mass being transferred rapidly from one hand to the other, thus facil-

Fig. 2.



Method of removing a bandage.

itating its removal and preventing the part becoming entangled in its loops (Fig. 2).

Varieties of Bandages.

The Circular Bandage.—This bandage consists of a few circular turns around a part, each turn covering accurately the preceding turn (Fig. 429, *b*). This variety of bandage may be used to retain a dressing to a portion of the head, neck, or limbs, or to hold a compress upon the veins of the extremities in the case of wounds or before or after performing venesection.

The Oblique Bandage.—In this form of bandaging the turns are carried obliquely over the parts, leaving uncovered spaces between the

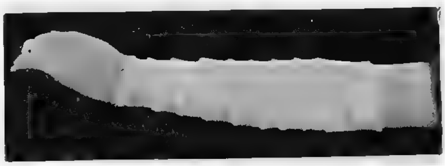
FIG. 3.

Oblique bandage.

successive turns (Fig. 3). Its principal use is for securing temporary dressings.

The Spiral Bandage.—In this bandage the turns are carried around the parts in a spiral direction, each turn overlapping the previous one usually one-third or one-half; it may be applied as an ascending spiral

FIG. 4.



Ascending spiral bandage.

(Fig. 4) or as a descending spiral (Fig. 5). This bandage may be

FIG. 5.

Descending spiral bandage.

used to cover a part which does not increase too rapidly in diameter; for instance, the abdomen, chest, or arm.

The Spiral Reversed Bandage.—This bandage is a spiral bandage, but differs from the ordinary spiral bandage in having its turns folded back or reversed as it ascends a part the diameter of which gradually increases. By its use it is possible to cover by spiral turns a part conical in shape, so as to make equable pressure upon all parts of the surface.

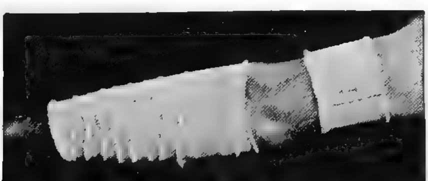
The reverses are made as follows: After fixing the initial extremity of the roller, as the part increases in diameter the bandage is carried off a little obliquely to the axis of the limb from three to six inches; the index finger or thumb of the disengaged hand is placed upon the body of the bandage to keep it securely in place upon the limb; the hand holding the roller is carried a little toward the limb to slacken the unwound portion of the bandage, and by changing the position of the hand holding the bandage from extreme supination to pronation the reverse is made (Fig. 6). Care should be taken not to attempt to make the reverse while the bandage is tense, for by so doing the bandage is twisted into a cord which is unsightly and uncomfortable to the patient, instead of forming a closely-fitting reverse. The reverse should be completed before the bandage is carried around the limb, and when it has been completed the bandage should be slightly tightened, so as to conform to the part accurately. The reverses should be in line, to have the bandage present a good appearance, and care should be taken that the reverses are not made over salient parts of the skeleton, for if they occupy such position they cause creases of the skin and become uncomfortable to the patient. To make reverses neatly and have them in line requires skill and practice; a well-applied spiral reversed bandage is a test of a competent bandager.

FIG. 6.

Method of making reverses.

The Spica Bandage.—When the turns of the roller cross each other in the form of the Greek letter *lambda,* leaving the previous turn about one-third uncovered, the bandage is known as a spica bandage (Fig. 7).

FIG. 7.



a Spica bandage. *b* Circular bandage.

The spica bandages are especially serviceable as a means of retaining surgical dressings upon the shoulders, groin, or foot.

Figure-of-8 Bandage.—This bandage receives its name from the turns being applied so as to form the figure of 8. This method of application is made use of in the Barton bandage, the bandages of the knee and elbow, and many other bandages.

Recurrent Bandage.—This bandage derives its name from the fact that the roller after covering a certain portion of the surface is reflected and brought back to the point of starting; it is then reversed and carried toward the opposite point; and this manipulation is continued until the part is covered in by these recurrent turns, which are then secured by a few circular turns passed around the part (Fig. 8). This is the bandage usually employed in the dressings of stumps.

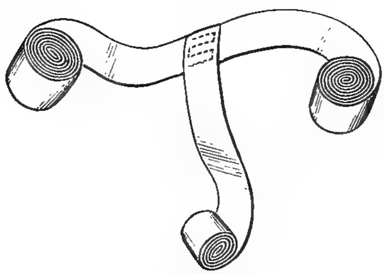
Fig. 8.

Recurrent bandage.

Compound Bandages.—These bandages are usually formed of several pieces of muslin or other material sewed or pinned together, and are employed to fulfil some special indication in the application of dressings to particular parts of the body. The most useful of the compound bandages are the T-bandages and the many-tailed bandages.

T-Bandages.—The single T-bandage consists of a horizontal band, to which is attached, about its middle, another band in a vertical direction: the horizontal piece should be twice the length of the vertical piece (Fig. 9). The single T-bandage may be used to retain dressings to the head, the horizontal piece being passed around the head from the occiput to the forehead, the vertical piece being passed over the head and secured to the horizontal piece; the shape and width of the two pieces being varied according to the indications. In applying dressings to the anal region or perineum, or in securing a catheter in a perineal wound, the single T-bandage will be found most useful. In applying a T-bandage for this purpose, the body of the bandage is placed over the spine just above the pelvis, and the horizontal portion is tied around the abdomen. The free extremity is split into two tails for about two-thirds of its length, and is carried over the anal region and brought up between the thighs, the terminal strips passing one on each side of the scrotum and being secured to the horizontal strip in front. The single T-bandage may be variously modified according to the indications which are to be met; for instance, in applying a dressing to the breasts the horizontal strip passing around the chest may be made ten or twelve inches in width; a vertical strip, two inches in width, passes from the back over the shoulder and is secured to the horizontal strip in front (Fig. 10). It may also be modified to apply dressings to particular parts of the body; for instance, to the groin, in which case a piece of muslin six inches wide at its base and thirty-six inches long is sewed

Fig. 9.



Single T-bandage.

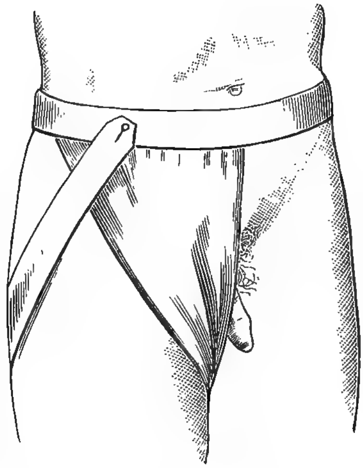
to a horizontal piece of muslin one and a half yards long and two inches in width. It may be applied as in Fig. 11 to hold dressings to this part.

Double T-bandage.—The double T-bandage differs from the single T-

Fig. 10.

Single T-bandage for chest.

Fig. 11.



T-bandage of groin.

bandage in having two vertical strips attached to the horizontal strip, and it may be used for much the same purpose as the single T-bandage. It may be conveniently used for retaining dressings to the chest, breasts, or abdomen; when used for this purpose the horizontal portion should be from eight to ten inches wide, and long enough to pass one and a quarter times about the chest or abdomen; two vertical strips, two inches wide and twenty inches long, should be attached to the horizontal strip a short distance apart, near its middle. In applying this bandage to the chest the horizontal strip is passed around the chest, so that the vertical strips occupy a position on either side of the spine; the overlapping end

Fig. 12.

Double T-bandage of chest.

Fig. 13.

Double T-bandage of nose.

of the horizontal portion is secured by pins or safety-pins, and the vertical strips are next carried, one over each shoulder, and secured to the other portion of the bandage in front of the chest (Fig. 12). The

double T-bandage may also be used to secure dressings to the nose, in which event the strips should be quite narrow, about one inch in width, and should be applied as shown in Fig. 13.

Many-tailed Bandages or Slings.—These bandages are prepared from pieces of muslin, which are split at each extremity into two, three, or more tails up to within a few inches of their centres, their width and length being regulated by the part of the body to which they are to be applied.

The four-tailed bandage may be found useful as a temporary dressing in cases of fracture of the jaw or to hold dressings to the chin. It may be prepared by taking a portion of a roller bandage three inches wide and one yard in length, and splitting each extremity up to within two inches of the centre, and it is then applied as seen in Fig. 14. A four-

Fig. 14.

Four-tailed bandage of chin.

Fig. 15.

Four-tailed bandage of head.

tailed bandage may also be used to retain dressings to the scalp, and can be prepared by taking a piece of muslin one and a quarter yards long and six or eight inches in width, splitting it at each extremity into two tails within six inches of the centre; it may then be applied as seen in Fig. 15. A four-tailed bandage may also be used in the temporary dressing of fracture of the clavicle; the body of the bandage being placed upon the elbow of the injured side, the two tails should be passed around the body and tied, fixing the arm to the side; two tails should pass over the sound shoulder, and their ends should be secured by tying.

The many-tailed bandage may also be used for holding dressings in contact with the abdomen or trunk, and this is the bandage which many surgeons employ to hold dressings to a laparotomy wound and to give support to the abdominal walls after this operation. In preparing this bandage a strip of muslin or flannel, one and a half yards in length and eighteen to twenty inches in width, is required; the extremities may be split so as to form an eight-tailed bandage. In applying this bandage to the abdomen the body of the bandage is placed upon the patient's back, and the tails are brought around the abdomen and overlap each other, and when sufficiently firmly drawn to make the desired amount of pressure they are secured by means of safety-pins.

Handkerchief Bandages.—The use of handkerchiefs or square pieces of muslin for the temporary dressings of wounds, fracture, or dislocation was advocated many years ago by M. Mayor, a Swiss surgeon, who wrote an extensive work upon this subject. He employed a handkerchief or a square piece of muslin, and by various modifications in the application of these developed a number of very ingenious bandages in which the handkerchief or *square* may be used as an *oblong*, made by folding the square once or twice on itself; as a *triangle*, made by bringing together the diagonal angles of the square; or as a *cravat* or *cord*.

The names of the various handkerchief bandages are derived from the shape of the handkerchiefs used and the parts to which they are to be applied; the names also serve as guides to their application. It is to be remembered that the base of the triangle or the body of the cravat is to be placed upon the portion the designation of which forms the first portion of the name of the bandage; thus, in the fronto-occipital triangle the shape of the handkerchief is given, and we know that the base of the triangle is to be applied to the forehead and then passed to the occiput. In using the cravat the same rule applies; thus, in the bis-axillary cravat the body of the cravat is placed in the axilla of the affected side, the extremities cross over the corresponding shoulder, and are carried over the chest, one before, the other behind, to the axilla of the opposite side, where they are secured.

The following are a few of the many ingenious bandages devised by Mayor as substitutes for the roller bandage. It is well to bear in mind

Fig. 16.

Occipito-frontal triangle.

this system of dressing: the occasion may occur in which other means of bandaging could not be obtained, and the application of handkerchief bandages might answer a useful purpose for temporary dressings, but they will never take the place of the roller bandage, which can be

applied with much greater nicety and exactness and certainly presents a much neater appearance.

The Occipito-frontal Triangle.—To apply this handkerchief, place the base of the triangle on the nape of the neck and bring the apex forward over the head, allowing it to hang down in front; knot the extremities around the forehead, and turn up the apex over the knot and pin it to the body (Fig. 16).

Mento-vertico-occipital Cravat.—In applying this handkerchief the middle of the base of the cravat is placed under the chin, the extremities are then carried to the vertex of the skull and are crossed at that point, and the ends are carried down over the parietal region and secured by a knot at the occiput (Fig. 17). Another method of applying this

FIG. 17.

Mento-vertico-occipital cravat.

cravat consists in placing the base of the cravat under the chin and carrying the extremities over the vertex, crossing them at that point, then carrying them downward to the occiput, crossing them at this point, and passing them forward around the front portion of the chin and securing the ends by a knot. The turns of the cravat correspond exactly to those of the Barton bandage for the head, and this dressing, as well as the mento-vertico-occipital cravat previously described, may be used as a temporary dressing to secure fixation in cases of fracture of the upper or lower jaw (Fig. 18).

The Bis-axillary Cravat.—The body of the cravat is placed in the axilla and the ends are brought up, one in front and one behind the axilla, and are made to cross over the shoulder; the extremities are then carried across the chest and back respectively to the opposite axilla, where they are secured by tying. This handkerchief may be used to secure dressings in the axilla or to hold dressings to the shoulder (Fig. 19).

The Dorso-axillary Cravat.—This handkerchief is applied by placing the body of the cravat upon the spine, and carrying one extremity over the shoulder and through the axilla backward to meet the other extrem-

Fig. 18.

Mento-vertico-occipital cravat modified.

ity, which has been carried through the axilla and over the other shoulder to the back, where the ends are secured. This handkerchief

Fig. 19.

Bis-axillary cravat.

may be made to hold dressings to the axilla or to the upper portion of the back (Fig. 20).

The Triangular Cap or Suspensory of the Breast.—The base of the

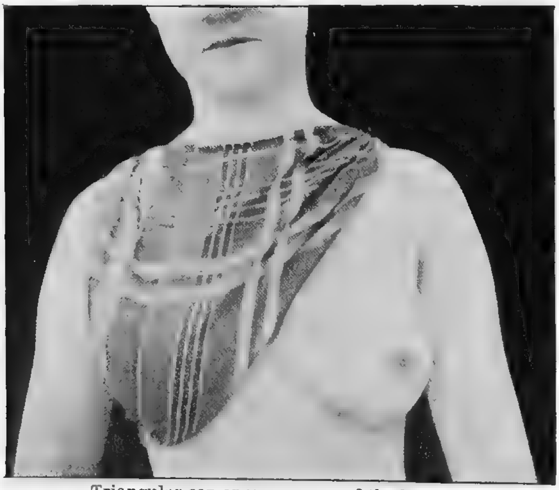
handkerchief, folded into a triangle, is placed over the affected breast, and one end is carried beneath the axilla, and the other end is conducted around the opposite side of the neck to be tied together on the back;

FIG. 20.

Dorso-axillary cravat.

the apex should then be brought up and passed over the shoulder of the affected side and fastened to the bandage behind (Fig. 21). This hand-

FIG. 21.



Triangular cap or suspensory of the breast.

kerchief is a convenient method of slinging the breast in nursing women or holding a dressing to the breast.

Ilio-femoral Triangle.—In applying this handkerchief a long cravat is fastened around the waist; the base of the triangle is then placed in the gluteo-femoral fold, and its extremities are fastened around the thigh, and the apex is carried up and passed beneath the cravat around the waist, and is turned down and pinned to the body of the triangle (Fig. 22). This handkerchief may be used to retain dressings to the region

Fig. 22.

Ilio-femoral triangle.

of the buttock, hip, or groin: by unpinning the apex and turning it down ready access can be had to the parts beneath without disturbing the patient.

Bandages of the Head and Neck.

Barton's Bandage.—*Roller two inches in width, six yards in length.*—Application.—The initial extremity of the roller should be placed on the head just behind the mastoid process, and the bandage should then be carried under the occipital protuberance obliquely upward, and under and in front of the parietal eminence across the vertex of the skull, then downward over the zygomatic arch, under the chin, thence upward over the opposite zygomatic arch and over the top of the head, crossing the first turn, which was made as nearly as possible in the median line of the skull, then carry the roller under the parietal eminence to the point of starting. The bandage is then passed obliquely around under the occipital protuberance and forward under the ear to the front of the chin, thence back to the point from which the roller started. These figure-of-8 turns over the head and the circular turns over the occiput to the chin should be repeated, each turn exactly overlapping the preceding one until the bandage is exhausted (Fig. 23). The extremities should then be secured by a pin, and pins should be introduced at the points where the turns

cross each other to give additional fixation to the bandage. In applying the bandage care should be taken to see that the turns overlap each other

FIG. 23.

Barton's bandage.

exactly, and that the turns passing over the vertex cross as near as possible in the median line of the skull.

FIG. 24.

Modified Barton's bandage.

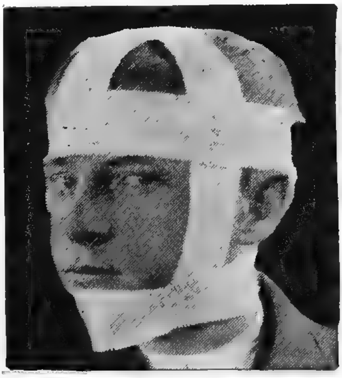
Modified Barton's Bandage.—To obtain additional security in the application of the Barton bandage a turn of the bandage passing from the

occiput to the forehead may be made, this turn being interposed between the turns of the bandage as ordinarily applied (Fig. 24). In applying this bandage, after the first set of turns has been completed—that is, after the bandage has been brought back to the occiput—the bandage is carried forward upon the head just over the ear, around the forehead, and backward above the ear on the opposite side of the occiput; this being done, the ordinary figure-of-8 and circular turns are made, and when these have been completed another occipito-frontal turn may be made as described above, and this may be repeated as often as is desired until the bandage is exhausted, when the extremity is fastened with a pin, and pins are also introduced at all points at which the turns cross.

Use.—This is one of the most useful of the bandages of the head, being employed to secure fixation to the jaw in cases of fracture or dislocation, and for the application of dressings to the chin. It may also be employed in slinging patients for the application of a plaster-of-Paris bandage in cases of disease of the spine, a stout cord or a piece of bandage three inches in width and one yard long being passed under the turns passing over the vertex; this cord is then secured to the cross-bar of the extension apparatus; and this will be found as comfortable to the patient as the ordinary head-gear employed, and much less likely to slip out of place and interfere with the breathing of the patient.

Gibson's Bandage.—*Roller two inches in width, six yards in length.*—Application.—The initial extremity of the roller should be placed upon the vertex of the skull on a line with the anterior portion of the ear; the bandage is then carried downward in front of the ear to the chin, and passed under the chin, and is carried upward on the same line until it reaches the point of starting. The same turns are repeated until three complete sets of turns have been made; the bandage is then continued until it reaches a point just above the ear, when it is reversed and is carried backward around the occiput, and is continued round the head and forehead until it reaches its point of origin; these circular turns are repeated until three turns have been made. When the bandage reaches the occiput, having completed these three turns, it is allowed to drop down to the base of the skull, and it is then carried forward below the ear and around the chin, being brought back upon the opposite side of the head and neck to the point of origin. These turns are repeated until three complete turns have been made, and upon the completion of these turns the bandage is reversed and carried forward over the occiput and vertex to the forehead, and its extremity is here secured by a pin; pins should also be applied where the turns of the bandage cross each other (Fig. 25).

Fig. 25.



Gibson's bandage.

Use.—This bandage may be used to fix the lower jaw in cases of fracture or dislocation of the jaw, but is very apt to change its position, and is therefore not so satisfactory as the Barton bandage for this purpose.

Oblique Bandage of the Angle of the Jaw.—*Roller two inches in width, six yards in length.*—Application.—The initial extremity of the roller is placed just in front of and above the left ear, and if the left angle of the jaw is to be covered in, the bandage is to be carried from left to right, making two complete turns around the cranium from the occiput to the forehead. If, however, the right angle of the lower jaw is to be covered in, the turns should be made in the opposite direction. Having made two turns from the occiput to the forehead, the bandage is allowed to drop down upon the neck, and is carried forward under the ear and under the chin to the angle of the jaw; it is now carried upward close to the edge of the orbit and obliquely over the vertex of the skull, then down behind the right ear, continuing these oblique turns under the chin to the angle of the left jaw, where it ascends in the same direction as the previous turn. Three or four of these oblique turns are made, each turn overlapping the preceding one and passing from the edge of the orbit toward the ear until the space is covered in; the bandage is then carried to the point just above the ear on the opposite side, is reversed, and finished with one or two circular turns from the occiput to the forehead, the extremity being secured by a pin (Fig. 26).

Fig. 26.

Oblique bandage of angle of the jaw.

Use.—This is one of the most useful of the head bandages; it may be used with a compress in treating fractures of the angle of the lower jaw, for holding dressings to the lower part of the chin and to the vault of the cranium, and it is especially useful in retaining dressings to the sides of the face and the parotid region. It may be applied to cover either the right or left side of the face, and holds its position most securely, having little tendency to become displaced.

Fig. 27.

Recurrent bandage of the head.

Recurrent Bandage of the Head.—*Roller two inches in width, six yards in length.*—Application.—The initial extremity of the roller is placed upon the lower part of the forehead, and the bandage is carried twice around the head from the forehead to the occiput to secure it. When the bandage is brought back to the median line of the forehead it is reversed, and the reversed turn is held by the finger of the left hand while the roller is carried over the top of the head along the sagittal suture to a point just below the occipital protuberance; here it is reversed again, and the reverse is held by an assistant while the roller is carried back to the forehead in an elliptical course, each turn covering in two-thirds of the preceding turn. These turns are repeated

with successive reverses at the forehead and occiput until one side of the head is completely covered in, and when this is accomplished a circular turn is made from the forehead to the occiput to hold the reverses in place. The opposite side of the head is next covered in by elliptical reversed turns made in the same manner, and when this has been accomplished two or three circular turns are carried around the head from the forehead to the occiput to fix the previous turns. Pins should be applied at the forehead and occiput at the points where the reversed turns concentrate (Fig. 27).

USE.—This bandage when well applied is one of the neatest of the head bandages, and is useful to retain dressings to the vault of the cranium in the treatment of wounds of the scalp in this region; also in holding dressings to fractures of the cranium and to wounds after the operation of trephining. In restless patients it will sometimes become displaced, and it may be rendered more secure by pinning a strip of bandage to the circular turn in front of the ear and carrying it down under the chin and up to a corresponding point on the opposite side, where it is pinned to the circular turn; or one or two oblique turns, passing from the circular turn over the vertex of the skull downward behind the ear, under the chin and up to the circular turn in front of the ear, may be applied. The course of these turns is the same as those applied in the *oblique bandage of the angle of the jaw*, the extremity being secured by a pin.

Transverse Recurrent Bandage of Head.—*Roller two inches in width, six yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the lower part of the forehead, and the bandage is carried twice around the head from the forehead to the occiput to secure it. The head is then covered in by transverse turns of the bandage: the first turn, starting from a point behind the ear on one side, is carried below the occiput to a corresponding point behind the opposite ear, and ascending transverse turns are then made and carried over the head, each turn covering in about two-thirds of the preceding turn, until the forehead is reached, and when this has been reached two or three circular turns are carried around the head from the forehead to the occiput to fix the recurrent turns. Pins should be applied at the point of starting of the reversed turns behind the ears, and at the occiput and forehead (Fig. 28).

FIG. 28.

Transverse recurrent bandage of head.

USE.—This bandage is used for the same purposes as the recurrent bandage of the head.

V-Bandage of the Head.—*Roller two inches in width, four yards in length.*—APPLICATION.—The initial extremity of the roller is secured by two turns of the bandage around the cranium from the forehead to the occiput, and when the roller reaches the occipital protuberance it is allowed to drop slightly, a little below this, and is carried forward below

the ear around the front of the chin and lower lip; it is then conducted backward to the point of starting. These turns, passing from the occiput to the forehead and from the occiput to the chin, are alternately made until a sufficient number have been applied, and the extremity is secured by a pin over the occiput (Fig. 29).

This bandage may be modified by carrying the turns from the occiput forward under the ear and around the upper lip and back to the occiput, and alternating these turns with the occipito-frontal turns; if employed in this way, a bandage one and a half inches in width should be used.

USE.—This bandage may be employed to hold dressings to the front of the chin, to the upper and lower lips in cases of wounds, or to give support to these parts after plastic operations.

FIG. 29.

V-bandage of the head.

FIG. 30.

Head-and-neck bandage.

Head-and-neck Bandage.—*Roller two inches in width, four yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the forehead and carried backward just above the ear to the occiput, and is then brought forward around the opposite side of the head to the point of starting. Two of these circular turns are made to fix the bandage, and when it is carried back to the occiput it is allowed to drop down slightly upon the neck, and is then carried around the neck, the turns around the head alternating with the neck turns until a sufficient number of these have been applied, when the extremity of the bandage is secured by a pin at the point of the crossing of the turns at the back of the head (Fig. 30).

USE.—This bandage may be found useful in securing dressings to the anterior or posterior portion of the neck or to the region of the occiput.

Care should be taken to apply it in such a manner that too much pressure is not made by the turns around the neck, which would be uncomfortable to the patient, and might seriously interfere with respiration.

Crossed Bandage of One Eye.—*Roller two inches in width, four yards in length.*—APPLICATION.—The initial extremity of the bandage

is placed upon the forehead, and fixed by two circular turns passing around the head from the occiput to the forehead; the roller is then carried back to the occiput and passed around this and brought forward below the ear, and, passing over the outer border of the cheek, is carried upward to the junction of the nose with the forehead, and is then conducted over the parietal protuberance downward to the occiput; a circular fronto-occipital turn is next made, and when the bandage is brought back to the occiput it is again brought forward to the cheek and ascends to the forehead, covering in two-thirds of the previous turn, and is again conducted back to the occiput; these turns are repeated, the oblique turns covering the eye alternating with circular turns around the head until the eye is completely enclosed (Fig. 31), and the bandage is finished by making a circular turn about the head and introducing a pin to secure its extremity. It will be found more comfortable to the patient to include the ear on the same side on which the eye is covered in the turns of the bandage.

FIG. 31.

Crossed bandage of one eye.

USE.—This bandage will be found useful in retaining dressings to one eye. It will be more comfortable to the patient if a flannel roller be used for this bandage as well as the bandage which includes both eyes.

Crossed Bandage of Both Eyes.—*Roller two inches in width, six yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the forehead, and secured by two circular turns of the bandage passing around the head from the forehead to the occiput; the roller is then carried downward behind the occiput and brought forward below the ear to the upper portion of the cheek; it is then carried upward to the junction of the nose with the forehead, and conducted over the parietal protuberance to the occiput; a circular turn is now made around the head from the occiput to the forehead, and the roller is carried from the occiput over the parietal protuberance of the opposite side forward to the junction of the nose with the forehead, then downward over the eye and outer portion of the cheek below the ear and back to the occiput; a circular turn around the head is next made, and this is followed by a repetition of the previous turns, ascending over one eye, descending over the other eye, each turn alternating with a circular turn around the head. These turns are repeated until both eyes are covered in, and the bandage is finished by making a circular turn around the head, the extremity being secured by a pin (Fig. 32). In this bandage both ears may be covered in or left uncovered.

FIG. 32.

Crossed bandage of both eyes.

Use.—This bandage may be used to apply dressings to both eyes, and both of these bandages covering the eyes are used where it is desired to make pressure; but for the simple application of a light dressing or of a bandage for the exclusion of light the Liebreich's bandage will be found more comfortable to the patient.

Occipito-facial Bandage.—*Roller two inches in width, four yards in length.*—The initial extremity of the roller is placed upon the vertex of the head, and the bandage is carried downward in front of the ear and under the jaw, and upward upon the opposite side in the same line to the vertex; two or three of these turns are made, one turn accurately covering in the other, and a reverse is made just above and in front of the ear, and two or three turns are made around the head from the occiput to the forehead, which completes the bandage (Fig. 33). Pins should be inserted at the points where the turns of the bandage cross each other.

Use.—This bandage is employed to secure dressings to the vertex, or to the temporal, occipital, or frontal regions.

Fig. 33.

Occipito-facial bandage.

Fig. 34.

Oblique bandage of the head.

Oblique Bandage of the Head.—*Roller two inches in width, four yards in length.*—The initial extremity of the bandage is placed upon the forehead, and is secured by two circular turns passing around the head from the forehead to the occiput. From the occiput the bandage is carried obliquely over the highest part of the lateral aspect of the head, which is to be covered in, and is passed over the forehead and back to the occiput, and is then carried to the forehead by a circular turn, then conducted obliquely over the other side of the head, and back to the occiput. These turns are repeated, so that each succeeding turn covers in three-fourths of the preceding turn until the sides of the head are covered in by descending turns, a circular turn being made between each set of oblique turns, and the bandage is completed by a circular turn passing around the head from the forehead to the occiput (Fig. 34). This bandage may be applied with descending or ascending turns.

Use.—This bandage is employed to make pressure upon or to hold dressings to the lateral aspects of the head.

Occipito-frontal Bandage.—*Roller two inches in width, four yards in length.*—Application.—The initial extremity of the bandage is placed upon the forehead, and a circular turn is made around the forehead and occiput to fix it. A circular turn is then made, passing around the head from a point below the occiput to a point just above the forehead; the next circular turn is made around the head, ascending posteriorly and descending anteriorly, and after a sufficient number of turns have been made to cover in the front and back of the head, the end of the bandage is secured with a pin (Fig. 35).

Use.—This bandage will be found useful in securing dressings to the forehead and anterior and posterior portion of the scalp.

Fig. 35.

Occipito-frontal bandage.

Bandages of the Upper Extremity.

Spiral Bandage of the Finger.—*Roller one inch in width, one and a half yards in length.*—Application.—The initial extremity of the roller is secured by two or three turns around the wrist; the bandage is then carried obliquely across the back of the hand to the base of the finger to be covered in, then to its tip by oblique turns; a circular turn is then made, and the finger is covered by ascending spiral or spiral reversed turns until its base is reached; the bandage is then carried obliquely across the back of the hand and finished by one or two circular turns around the wrist; the extremity may be pinned or may be split into two tails, which are tied around the wrist (Fig. 36).

Use.—This bandage is employed to retain dressings upon the finger and to secure splints in the treatment of fractures or dislocations of the phalanges.

Fig. 36.

Spiral bandage of the finger.

Gauntlet Bandage.—*Roller one inch in width, three yards in length.*—Application.—The initial extremity of the roller is fixed at the wrist by one or two circular turns of the bandage; it is then carried down to the tip of the thumb by an oblique turn of the roller, and this is covered in by spiral or spiral reversed turns to the metacarpo-phalangeal articulations; the roller is then carried back to the wrist and a circular turn is made around it, and the bandage is now carried down to the tip

of the next finger by an oblique turn, which is covered in in the same manner. When all the fingers have been covered in, the bandage is finished by circular turns around the hand and wrist (Fig. 37).

Use.—This bandage may be employed to apply dressings to the fingers and hand in cases of wounds or fractures. It was formerly much employed in the treatment of burns of the fingers to prevent the opposed ulcerated surfaces from adhering, but its use for this purpose has been supplanted by wrapping each finger in a separate dressing and applying a dressing over the whole with a few recurrent and spiral turns of a wide roller, the application of this dressing being much less painful to the patient, and being at the same time equally satisfactory.

Fig. 37.

Gauntlet bandage.

Fig. 38.

Spica bandage of the thumb.

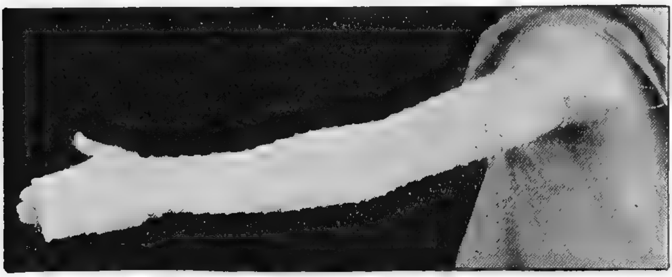
Spica Bandage of the Thumb.—*Roller one inch in width, three yards in length.*—Application.—The initial extremity of the roller is placed upon the wrist and fixed by two circular turns; then carry the roller obliquely over the dorsal surface of the thumb to its distal extremity; next make a circular or spiral turn around the thumb, and carry the bandage upward over the back of the thumb to the wrist, around which a circular turn should be made. The roller is next carried around the thumb and wrist, making figure-of-8 turns, each turn overlapping the previous one two-thirds as it ascends the thumb, and each figure-of-8 turn alternating with a circular turn about the wrist. These turns are repeated until the thumb is completely covered in with spica turns, and the bandage is finished by a circular turn around the wrist (Fig. 38).

Use.—This bandage is employed to apply dressings to the dorsal surface of the thumb and for the retention of splints in the dressing of fractures or dislocations of the bones of the thumb.

Spiral Reversed Bandage of the Upper Extremity.—*Roller two and a half inches in width, seven yards in length.*—Application.—The initial extremity of the roller is placed upon the wrist and secured by

two turns around the wrist; the bandage is then carried obliquely across the back of the hand to the second joint of the fingers, where a circular turn should be made; the hand is covered in by two or three ascending spiral or spiral reversed turns. When the thumb has been reached its base and the wrist are covered in by two figure-of-8 turns; the bandage is then carried up the forearm by spiral and spiral reversed turns until the elbow is reached; this may be covered in with spiral reversed turns, and the bandage is next carried up the arm with spiral reversed turns to the axilla (Fig. 39). If on reaching the elbow the arm is bent or is to

Fig. 39.



Spiral reversed bandage of the upper extremity.

be flexed in the subsequent dressing, the elbow should be covered in with figure-of-8 turns, and when this has been done the arm may be covered in with spiral reversed turns. When properly applied the reverses should be in line, and should not be made over the prominent ridge of the ulna.

Use.—This is one of the most generally employed of all the roller bandages; it constitutes the primary roller which is applied in the dressing of fractures of the humerus, and is also the bandage employed in holding dressings to the arm and forearm, and in securing splints to these parts in the treatment of fractures and dislocations.

Figure-of-8 Bandage of the Elbow.—*Roller two inches in width, four yards in length.*—Application.—The initial extremity of the bandage is placed upon the forearm a short distance below the elbow-joint, and fixed by one or two circular turns, the arm being flexed. The bandage is then carried by an oblique turn across the flexure of the elbow-joint, and passed around the arm a few inches above the elbow; a circular turn is then made, and the roller is next carried across the flexure of the elbow and passed around the forearm. These turns are repeated, and turns from the forearm ascending and those from the arm descending, each set of turns crossing in the flexure of the elbow until it is covered in, and a final turn is passed circularly around the elbow-joint (Fig. 40). This bandage is sometimes applied by first making one or two circular turns around the elbow and then applying the figure-of-8 turns as previously described.

Use.—This bandage is often employed as a part of the spiral reversed bandage of the upper extremity when the arm is to be flexed, and is also used to hold dressings to the region of the elbow-joint. It was formerly

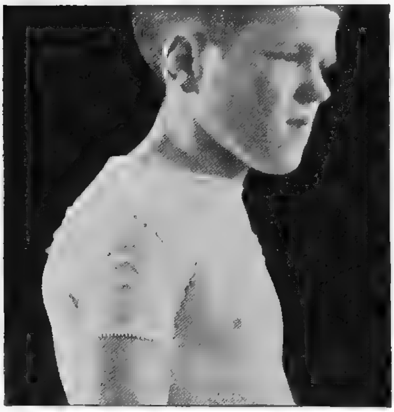
much used to hold the compress upon the wound resulting from venesection at the elbow.

Fig. 40.

Figure-of-8 bandage of the elbow.

Spica Bandage of the Shoulder (ascending).—*Roller two and a half inches in width, seven yards in length.*—Application.—The initial extremity of the roller is placed obliquely upon the outer surface of the arm opposite the axillary fold, and fixed by one or two circular turns. If the right shoulder is to be covered, the bandage is next carried across the front of the chest to the axilla of the opposite side, then around the back of the chest to the point of starting upon the arm; then conduct the roller around the arm of this side up over the shoulder, across the front of the chest, through the opposite axilla and back over the posterior surface of the chest to the point of starting; continue to make these ascending turns, each turn overlapping the preceding one about two-thirds until the shoulder is covered in (Fig. 41), when the extremity of the bandage may be secured by a pin at the point of ending, or the last turn may be carried from the shoulder around the back of the neck and brought forward over the opposite shoulder and pinned to the turns which pass around the axilla. It should be remembered that the turns of the roller overlap each other exactly in the opposite axilla, and it will be found more comfortable to the patient to apply a little cotton wadding in the axilla to prevent the bandage from excoriating the skin of this part. Care should be taken to see that the turns are made in such a manner that the spica turns occupy, as nearly as possible, the median line of the shoulder. When

Fig. 41.

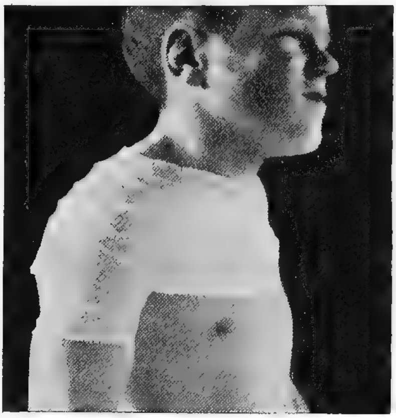


Spica bandage of shoulder (ascending).

this bandage is applied to the left shoulder, after fixing the initial extremity by circular turns around the arm the roller should be carried over the back of the chest to the axilla of the opposite side, and then brought back to the point of starting; the succeeding turns are then applied in the same manner.

Spica Bandage of the Shoulder (descending).—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller should be fixed upon the arm as near as possible to the axillary fold by one or two circular turns, and if applied to the right shoulder the bandage should be passed under the axilla and carried obliquely over the shoulder to the base of the neck, then downward across the front of the chest to the axilla of the opposite side; from the axilla the roller is carried over the back of the chest to the base of the neck, so as to cross the first turn at this point; it is then carried to the axilla and through this, then back to the neck, the turns descending toward the shoulder. These turns, taking the same course, are repeated, each turn overlapping two-thirds of the previous one until the shoulder is covered in and the circular turn around the arm is reached, at which point the extremity is secured by a pin (Fig. 42).

FIG. 42.



Spica bandage of shoulder (descending).

USE.—The spica bandages of the shoulder are employed to hold dressings to the shoulder, to hold compresses over the acromial end of the clavicle in case of dislocation of that portion of the bone, to retain the shoulder-cap used in the treatment of fractures of the upper portion of the humerus, and to retain dressings to the axilla.

Velpeau's Bandage.—*Two rollers two and a half inches in width, seven yards in length.*—APPLICATION.—The patient should place the fingers of the hand of the affected side on the opposite shoulder; the initial end of the roller should be placed on the body of the scapula of the sound side and secured by a turn made by carrying the bandage over the shoulder of the affected side, near its outer portion, then conducting it downward over the outer and posterior surface of the arm of the same side, behind the point of the elbow, and obliquely across the front of the chest to the axilla of the opposite side, thence to the point of starting. This turn should be repeated, to fix the initial extremity of the bandage. Having completed the second turn, carry the roller transversely around the thorax, passing over the flexed elbow of the affected side, from this point to the axilla, and through this to the back. From this point the roller is carried over the shoulder and down the outer and posterior surface of the arm behind the elbow, and obliquely across the front of the chest through the axilla to the back, and, continuing, passes transversely across the back of the chest to the elbow, which it encircles, then passes to the axilla. These alternating turns are repeated until the arm

and forearm are bound firmly to the side and chest. The vertical turns over the shoulder, each turn covering in two-thirds of the previous turn, and ascending from the point of the shoulder toward the neck and from the posterior surface of the arm toward the elbow, are applied until the point of the elbow is reached. The transverse turns passing around the chest and arm are so applied that they ascend from the point of the elbow toward the shoulder, each turn covering in one-third of the previous one, and the last turn should pass transversely around the shoulder and chest, covering the wrist (Fig. 43).

FIG. 43.

Velpeau's bandage.

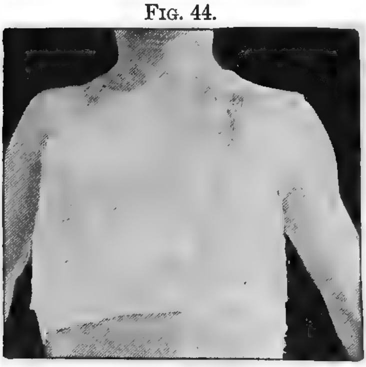
The extremity of the bandage should be secured by a pin where it ends, and additional fixation will be secured by introducing a number of pins at the points where the turns of the bandage cross each other.

USE.—This bandage is employed to fix the arm in the treatment of certain fractures of the clavicle and scapula; also to secure fixation of the humerus after the reduction of dislocations of the shoulder-joint.

Desault's Bandage.—*Three rollers two and a half inches in width, seven yards in length.*—A wedge-shaped pad to fit in the axilla is also required. These rollers are known as the *first, second,* and *third* rollers.

First roller of Desault's bandage.—APPLICATION.—Before applying the first roller the arm of the patient on the injured side should be elevated and carried off at right angles to the body; the wedge-shaped pad with its base in the axilla should next be applied to the side of the chest, and the initial extremity of the roller is placed upon the middle of the pad and fixed by two or three circular turns around the chest; the bandage is then carried down the chest by oblique circular turns until the lower extremity of the pad is reached, and it is then carried up the chest until the upper extremity of the pad is reached, when it is conducted obliquely across the front of the chest to the sound shoulder and passed under the axilla, brought over the shoulder and conducted around the chest, where it is secured (Fig. 44).

FIG. 44.

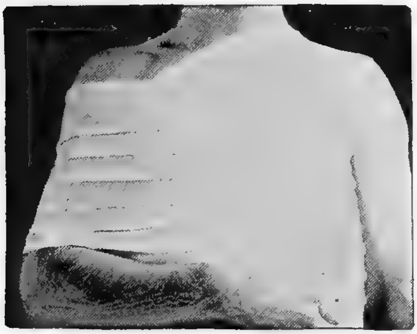


First roller of Desault's bandage.

Second roller of Desault's bandage.—APPLICATION.—The arm should be brought down against the side, so as to press upon the pad previously applied, and the forearm should be flexed upon the arm and brought across the lower portion of the chest. The initial extremity of the roller is placed in the axilla of the sound side, and the bandage is carried

around the chest and over the arm of the injured side, making a circular turn around the chest to fix it; then spiral turns are made around the chest from above downward until the elbow is reached, the turns being more firmly applied as they descend, and when this point is reached the end of the bandage is secured. Or the initial extremity of the bandage may be placed upon the chest of the sound side, and a circular turn may be made to fix it, and then spiral turns including the chest and arm may be made from below upward until the axilla is reached (Fig. 45).

Fig. 45.



Second roller of Desault's bandage.

Fig. 46.

Third roller of Desault's bandage.

Third roller of Desault's bandage.—Application.—The initial extremity of the roller is placed in the axilla of the sound side, and the bandage is carried obliquely over the front of the chest to the shoulder of the injured side, passed over this, and conducted down the back of the arm to the elbow, thence obliquely upward over the upper fifth of the forearm to the axilla of the sound side. From this point it is carried backward obliquely over the back of the chest to the shoulder; crossing the previous shoulder-turn, it is conducted down the front of the arm to the elbow, then around this and backward obliquely over the back of the chest to the axilla of the sound side. These turns are repeated until three sets of turns have been applied, which should overlie each other exactly (Fig. 46). The course of the turns of the third roller is considered the most difficult to remember, and the student may be assisted in its correct application by remembering that all the turns start at the axilla, pass to the shoulder, and then to the elbow, and from the elbow always return to the starting-point, the axilla. The turns of the third roller make two triangles, one on the anterior surface of the chest, the other upon the back.

After the application of the three rollers the hand and uncovered portion of the forearm should be supported in a sling suspended from the neck.

Use.—This bandage, applied completely, or some one of its various rollers, is employed in the treatment of fractures of the clavicle.

Arm-and-chest Bandage.—*Roller two and a half inches in width, seven yards in length.*—Before applying this bandage the arm should be placed against the side of the chest and a folded towel or a pad of cotton should be placed in the axilla and allowed to extend from the axilla to

the elbow; the latter is used to prevent the opposing surfaces of skin from becoming excoriated by contact.

APPLICATION.—The initial extremity of the bandage is placed upon the spine at a point opposite the elbow-joint, and it is fixed by a turn or two passing around the arm and chest; the bandage is then continued by making ascending spiral turns, covering in the arm and chest, until the axilla is reached; at this point the bandage is carried through the axilla and over the back of the chest to the top of the opposite shoulder, and it is then conducted down the front of the arm to the elbow, is passed between the arm and chest and carried up the back of the arm to the shoulder, and is then passed obliquely across the front of the chest and is secured upon the back of the chest. Pins should be introduced at the points of crossing of the bandage (Fig. 47).

FIG. 47.

Arm-and-chest bandage.

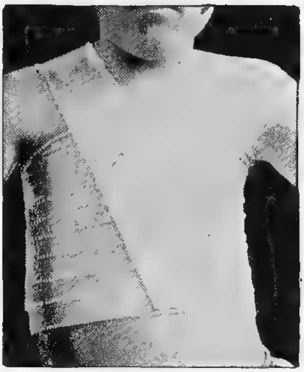
USE.—This bandage will be found useful in fixing the arm to the body and in fixing the shoulder-joint where it is desirable to allow the forearm to be free. It is employed in the treatment of fractures of the shaft and neck of the humerus, to fix the arm and hold splints in position.

BANDAGES OF THE TRUNK.

Spiral Bandage of the Chest.—*Roller three inches in width, nine yards in length.*—APPLICATION.—The initial extremity of the roller is applied to the anterior portion of the waist, and fixed by one or two circular turns; the bandage is then carried upward, encircling the chest by ascending spiral turns, each turn covering in one-half of the previous

turn until the axillary fold is reached; the roller is next carried around the axilla to the back, and obliquely over this to the base of the neck of the opposite side, and then it may be passed down over the chest and pinned to the spiral turns at several points; a pin should also be inserted at the point where the last turn of the roller leaves the spiral turn upon the back of the chest (Fig. 48).

Fig. 48.



Spiral bandage of the chest.

USE.—This bandage is employed to hold dressings to the chest, and may be used as a temporary dressing in fractures of the ribs or sternum. Care should be taken that the bandage be not so tightly applied as to interfere with respiration.

Anterior Figure-of-8 Bandage of the Chest.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller should be placed in the axilla of one side, and the bandage is then carried obliquely across the anterior portion of the chest to the shoulder of the opposite side; it is then carried backward around the shoulder and through the axilla, and is next conducted obliquely over the anterior portion of the chest to the opposite shoulder, through the axilla and again back to the anterior portion of the chest, the turns crossing in the median line over the sternum. These turns should be repeated, ascending from the shoulder toward the neck, each turn overlapping three-fourths of the preceding one, until five or six turns have been applied, the end of the bandage being secured by a pin (Fig. 49), or it may be completed by a circular turn around the chest.

Fig. 49.

Anterior figure-of-8 bandage of the chest.

USE.—This bandage may be employed to bring the shoulders forward and to hold dressings to the anterior portion of the chest.

Posterior Figure-of-8 Bandage of the Chest.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller should be placed in the axilla of the left side, and the bandage is then carried obliquely across the back of the chest to the tip of the opposite shoulder; it is next carried through the axilla and

conducted across the posterior portion of the chest to the tip of the opposite shoulder, and passed through the axilla to the point of starting. These turns are repeated, ascending from the shoulder toward the neck, until five or six have been applied, the end of the bandage being secured

FIG. 50.

Posterior figure-of-8 bandage of the chest.

by a pin (Fig. 50). In applying both of these bandages the crosses of the bandage, either anterior or posterior, should be made in the median line of the chest.

USE.—This bandage may be employed to hold dressings to the posterior portion of the chest and to draw the shoulders backward.

Suspensory and Compressor Bandage of the Breast.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller should be placed upon the scapula of the affected side, and secured by two oblique turns carried over the opposite shoulder and conducted downward under the breast to be covered in, and then carried to the axilla of the same side. Next carry the roller transversely around the chest, covering in the lowest portion of the affected breast. These turns should be repeated, the oblique turns from the axilla over the shoulder alternating with the transverse turns around the chest until the breast is covered in, each series of turns ascending and covering two-thirds of the preceding turn (Fig. 51).

FIG. 51.

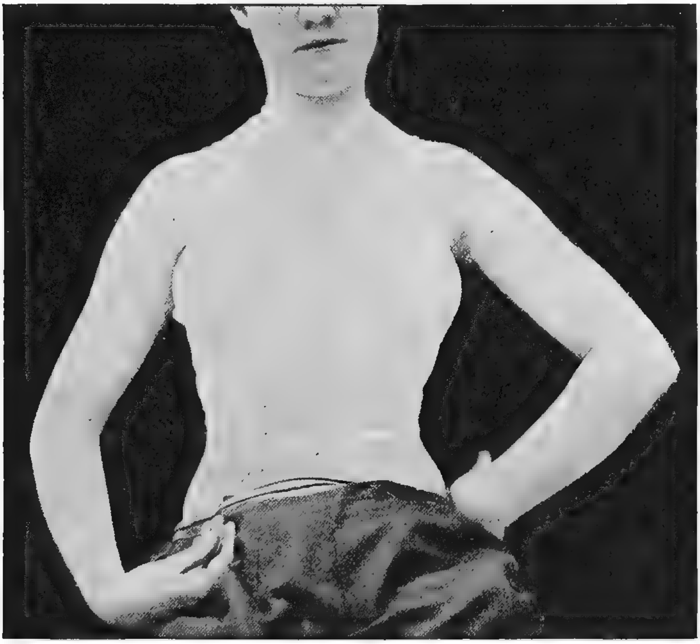
Suspensory and compressor bandage of the breast.

USE.—This bandage is employed to support the breast and to make compression at the same time; it may also be employed to hold dressings to the breast.

Suspensory and Compressor Bandage of Both Breasts.—*Two rollers two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the bandage should be secured by oblique turns of the axilla and shoulder as in the preceding bandage; the roller should next be carried transversely around the back to the breast, then under the breast and upward over the opposite shoulder,

then obliquely downward around the chest to the other side, being carried transversely over the lower portion of both breasts to the point of starting upon the back. Repeat these oblique turns from the shoulder to the breast and from the breast to the shoulder, and alternate them

FIG. 52.



Suspensory and compressor bandage of both breasts.

with a transverse turn around the chest and over both breasts. Both series of turns should ascend, and each turn should overlap two-thirds of the preceding one (Fig. 52).

USE.—This bandage is employed to support and compress both breasts and to retain dressings to them.

BANDAGES OF THE LOWER EXTREMITY.

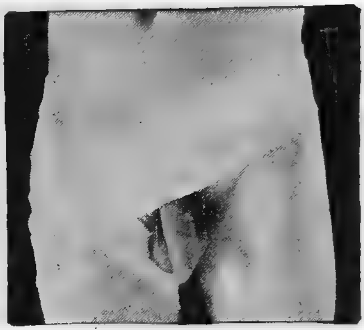
Single Spica Bandage of the Groin (ascending).—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—Place the initial extremity of the bandage upon the anterior portion of the right thigh just below the groin, and secure it by one or two circular turns around the thigh, or place the initial extremity of the roller obliquely upon the upper part of the thigh, and carry it behind the limb and upward around the outer side of the thigh to the abdomen, omitting the circular turns; then carry the bandage obliquely across the lower part of the abdomen to a point just below the crest of the left ilium, and conduct it transversely around the back of the pelvis to a corresponding point on the opposite side; then bring it obliquely downward to the groin over to the inner portion of the thigh, carrying

it around the limb, crossing the starting-turn in the middle line of the thigh. These turns are repeated, each turn ascending and covering in two-thirds of the previous turn, until six or eight complete turns have been made, and the bandage is secured at any point where it ends (Fig. 53).

FIG. 53.

Ascending spica bandage of the groin.

FIG. 54.



Descending spica bandage of the groin.

Single Spica Bandage of the Groin (descending).—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—Place the initial extremity of the roller obliquely upon the anterior surface of the right thigh, and secure it by one or two circular turns around the limb, or start the bandage with an oblique turn, as previously described; then carry the bandage obliquely across the abdomen to a point just below the crest of the ilium, and conduct it transversely around the back of the pelvis to a corresponding point on the opposite side; then bring it obliquely down over the lower portion of the abdomen, crossing the first turn, to the junction of the thigh with the scrotum; pass it under the thigh and bring it up over the lower part of the abdomen, and let it follow the course of the first turn. These turns are repeated, each turn descending and overlapping two-thirds of the previous turn until the groin is covered (Fig. 54). When either of these bandages is applied to the left groin, after the initial extremity of the roller is fixed it is carried first to the crest of the ilium of the same side, then around the back of the pelvis to a corresponding point on the opposite side, then obliquely across the lower part of the abdomen to the outer aspect of the thigh, being conveyed under this and brought up between the thigh and the scrotum, passing obliquely over the groin to follow the course of the original turn.

USE.—The spica bandages of the groin are employed to hold dressings to wounds in the inguinal region; for instance, to those resulting from herniotomy or from operation upon the glands of the groin. They are also employed to make pressure upon this region, and will often prove of use in the securing of compresses applied for the temporary retention of herniæ.

Spica Bandage of Buttock.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the bandage is placed upon the back of the thigh just below the gluteal fold, and is carried around the thigh and brought back to the posterior aspect of the limb, so as to fix and cross the starting turn near the middle of the thigh. It is next conducted obliquely across the thigh and buttocks and carried to the brim of the pelvis of the opposite side, when it is brought obliquely over the abdomen and back to the posterior surface of the thigh. There ascending turns are applied, each turn covering in about three-fourths of the preceding one, until the buttock is covered, and the bandage is then finished by one or two circular turns around the pelvis and abdomen (Fig. 55).

FIG. 55.

Spica bandage of buttock.

USE.—This bandage is employed to hold dressings to the upper posterior portion of the thigh or the buttock.

Figure-of-8 Bandage of the Knee.—*Roller two and a half inches in width, five yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the thigh three inches above the patella, and secured by two or three circular turns; then conduct the bandage over the outer condyle of the femur across the popliteal space to the inner border of the tibia, and around the anterior surface below the tubercle and head of the fibula, and make one circular turn; the roller should

FIG. 56.

Figure-of-8 bandage of the knee.

FIG. 57.

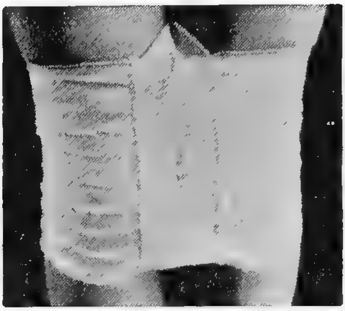


Figure-of-8 bandage of both knees.

then be carried obliquely across the popliteal space to the inner condyle of the femur, crossing the previous turn; then carry it around the front of the thigh to the outer condyle; repeat these turns, ascending toward the knee from the leg, and descending from the thigh toward the

knee, and finish the bandage by a circular turn over the patella (Fig. 56).

USE.—This bandage is employed to hold dressings to the knee-joint either anteriorly or posteriorly. These figure-of-8 turns are often employed in covering the knee in applying the spiral reversed bandage of the lower extremity when it is desired that the patient be allowed to bend the knee.

Figure-of-8 Bandage of Both Knees.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—Place the knees of the patient together with a compress between them; then place the initial extremity of the roller upon one thigh about three inches above the patella, and secure it by one or two circular turns around both thighs; then conduct the roller from the outer condyle of the femur obliquely across the popliteal spaces of both legs to the head of the fibula on the opposite side, making a circular turn around both legs; pass the roller from the head of the fibula on the opposite side across the popliteal space to the external condyle opposite the point of starting. Repeat these turns, descending from the thighs and ascending from the legs, until the knees are covered, and finish the bandage by carrying a turn of the bandage at right angles to the previous turns between the thighs and the legs (Fig. 57).

USE.—This bandage is employed to secure fixation of the limbs after operation upon the perineum, and may also be employed to obtain temporary fixation of the limbs in transporting cases of fracture of the neck of the femur and after the reduction of dislocations of the head of the femur.

Spica Bandage of the Foot.—*Roller two and a half inches in width, five yards in length.*—APPLICATION.—Fix the initial extremity of the roller upon the ankle and secure it by two circular turns; then carry the bandage obliquely over the dorsum of the foot to the metatarso-phalangeal articulation, and make a circular turn around the foot at this point; then continue it upward over the metatarsus by making two or three spiral reversed turns; next carry the bandage parallel with the inner or outer margin of the sole of the foot, according to whether it is applied to the right or left foot, directly across the posterior surface of the heel; thence along the opposite border of the foot and over the dorsum, crossing the original turn in the median line of the foot. This completes the first spica turn. These spica turns are repeated, gradually ascending by allowing each turn to cover in three-fourths of the preceding turn, until the foot is covered in with the exception of the posterior portion of the sole of the heel (Fig. 58). Care should be taken to see that the turns cross each other in the median line of the foot, and that they are kept parallel to each other throughout their course.

FIG. 58.

Spica bandage of the foot.

USE.—This bandage will be found very useful when it is desired to

make firm compression upon the foot or to retain dressings to it; it is especially useful in the treatment of sprains of the ankle or anterior tarsus.

Bandage of Foot covering the Heel (American).—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the leg just above the malleoli and fixed by two circular turns around the leg; the bandage is then carried obliquely across the dorsum of the foot to the metatarso-phalangeal articulation, at which point a circular turn is made; two or three spiral or spiral reversed turns are then made, ascending the foot; the roller is next carried directly over the point of the heel and continued back to the dorsum of the foot; thence beneath the instep around one side of the heel and up over the instep; from this point it is carried beneath the instep around the other side of the heel and up in front of the ankle, from which point it may be continued up the leg (Fig. 59).

USE.—This bandage is employed to cover in the foot and retain dressings to the foot and heel.

FIG. 59.

Bandage of foot covering the heel.

FIG. 60.

Bandage of foot not covering the heel.

Bandage of Foot not covering the Heel (French).—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—Fix the initial extremity of the roller upon the leg just above the malleoli, and secure it by two circular turns around the leg; the bandage is then carried obliquely across the dorsum of the foot to the metatarso-phalangeal articulation, and at this point a circular turn around the foot is made. The roller is now carried up the foot, covering it in with two or three spiral reversed turns, and at this point a figure-of-8 turn is made around the ankle and instep; this should be repeated once, which will cover in the foot with the exception of the heel; the bandage may then be continued up the leg with spiral reversed turns (Fig. 60).

USE.—This bandage may be employed to secure dressings to the foot, and is the one generally used to cover the foot in applying the spiral reversed bandage of the lower extremity.

Spiral Reversed Bandage of the Lower Extremity.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—The initial extremity of the roller is placed upon the leg just above the malleoli and secured by two circular turns, then carried obliquely over the

foot to the metatarso-phalangeal articulation; and here a circular turn is made around the foot; the foot is next covered in with two or three spiral reversed turns and two figure-of-8 turns of the ankle and instep, and just above the ankle one or two circular or spiral turns are made around the leg, and as the bandage is carried up the leg, as it increases in diameter, spiral reversed turns are made until it approaches the knee;

FIG. 61.

Spiral reversed bandage of the lower extremity.

at this point, if the limb is to be kept straight, the spiral reversed turns may be continued over this region and up upon the thigh. If the knee is to be bent, figure-of-8 turns may be applied until the knee is covered, and then the thigh may be covered with spiral reversed turns (Fig. 61). To cover in the thigh as well as the leg two bandages of the dimensions before given will be required. Care should be taken to keep the reverses in a line, and not to make them over the spine of the tibia, as they may thus become painful to the patient.

USE.—This is one of the most frequently employed of the roller bandages; it is used to apply pressure to the lower extremity, to retain dressings, and to secure splints in the treatment of fractures and dislocations.

FIG. 62.

Figure-of-8 bandage of the leg.

Figure-of-8 Bandage of the Leg.—*Roller two and a half inches in width, seven yards in length.*—APPLICATION.—This bandage differs

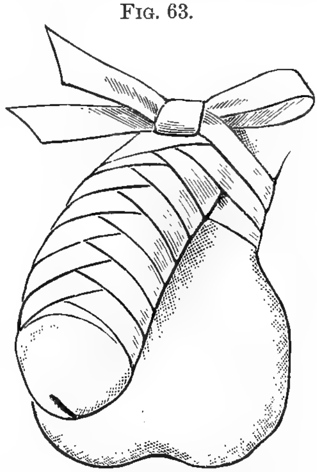
from the spiral reversed bandage of the lower extremity only in the fact that when the swell of the calf is reached figure-of-8 turns are made around the leg instead of spiral reversed turns. In applying the roller, when the calf of the leg is reached the bandage is carried obliquely around the leg and brought in front of the leg, and made to cross the starting turn in the median line; these turns are repeated until the calf of the leg has been covered in, and the bandage is finished with one or two circular turns just below the knee (Fig. 62).

USE.—This bandage holds its place more firmly than the ordinary spiral reversed bandage of the leg, and may be employed in the treatment of ulcers of the leg, in conjunction with strapping, where it is desirable to change the dressings at infrequent intervals and to allow the patient to walk about during the course of treatment.

SPECIAL BANDAGES.

Spiral Reversed Bandage of the Penis.—*Roller three quarters of an inch in width, thirty inches in length.*—APPLICATION.—Fix the initial extremity of the roller by two circular turns around the penis close to the pubis; then carry the bandage obliquely down to the corona glandis; from this point ascend the body of the penis by spiral reversed turns to the pubis and finish the bandage by two figure-of-8 turns around the neck of the scrotum and root of the penis; split the end of the bandage so as to form two tails, and secure it by tying these around the root of the penis (Fig. 63).

FIG. 63.



Spiral reversed bandage of the penis.

Recurrent Bandage of Stump.—*Roller two and a half inches in width, five to seven yards in length.*—APPLICATION.—Place the initial extremity of the roller upon the anterior or posterior surface of the limb a few inches above the extremity of the stump, and carry the bandage to the end of the stump, and then conduct it upward or downward on the limb, as the case may be, to a point directly opposite the point of starting; then bring the bandage back over the face of the stump to the point of starting, and continue these recurrent turns, each turn overlapping two-thirds of the previous one, until the face of the stump is covered; then reverse the bandage and secure the recurrent turns at their points of origin by two or three circular turns. The roller should next be carried obliquely down to the end of the stump, and a circular turn should be made around this; and the bandage should next be carried up the limb by spiral or spiral reversed turns beyond the point at which the recurrent turns terminated, and secured by one or two circular turns (Fig. 64).

In applying this bandage in very short stumps resulting from amputations at or near the shoulder- or hip-joint, after making the recurrent and spiral turns it will be found necessary to carry the bandage, in the

case of the shoulder, across the chest to the opposite axilla and back, and apply several of these turns; so in case of hip amputations it will be found best to finish the bandage with a few turns about the pelvis.

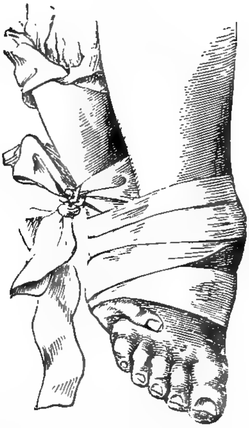
FIG. 64.

Recurrent bandage of stump.

Bandage for Securing the Hands and Feet in the Lithotomy Position.—*Roller two and a half inches in width, three yards in length.*—APPLICATION.—The hand of the patient should be brought down and made to grasp the outer side of the foot; the initial extremity of the roller is fixed by two circular turns around the wrist and ankle, and the bandage is then passed around the foot and hand, and these turns are alternated with turns around the wrist and ankle until the hand and foot are firmly secured. The same procedure is adopted with the hand and foot of the opposite side (Fig. 65).

USE.—This bandage is useful in securing the hands and feet while

FIG. 65.



Bandage for securing hands and feet for lithotomy.

FIG. 66.

Liebreich's eye bandage.

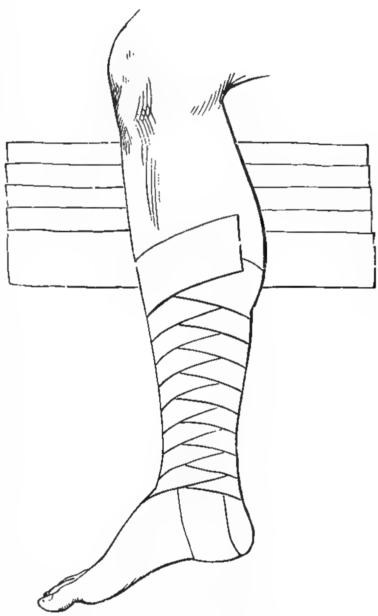
the patient is put in the lithotomy position for that operation or for perineal section.

Liebreich's Eye Bandage.—This bandage consists of a strip of flannel two and a half inches in width and from six to ten inches in length, to the extremities of which are sewed tapes. It may be applied transversely so as to cover both eyes, or obliquely so as to cover one eye only, and is secured by the tapes carried around the head and tied over the forehead (Fig. 66).

Use.—This bandage is used to hold compresses or dressings to the eye or eyes, and the elasticity of the flannel permits of its being applied so as to make a variable amount of pressure.

Bandage of Scultetus.—This is a compound bandage, consisting of a number of pieces of muslin, and may be prepared from a two-and-a-half or three-inch roller by cutting off strips long enough to encircle the part about one and one-third times. These strips are placed under the part in such a manner that the first piece shall be overlapped by the second, the second by the third, and so on from below upward; the pieces are then brought around the limb and the extremities of the last piece are secured by pins (Fig. 67). This bandage was formerly much employed in the treatment of compound fractures to secure dressings to the wound, and possessed the advantage that when a single strip became soiled it could be removed without disturbing the whole dressing, the new strip to be introduced being pinned to the extremity of the soiled piece to be removed, and then being drawn through by its removal. This bandage will often be found convenient in applying dressings to cases of excision of the joints where as little disturbance of the parts as possible is important in dressing the wounds. When the strips are attached to each other by a thread passed through each strip in the centre the bandage is known as *Pott's bandage.* This bandage is applied and secured in the same manner, but it possesses no advantages over the bandage of Scultetus.

Fig. 67.



Bandage of Scultetus.

Flannel Bandage.—These bandages are prepared from flannel, which is cut into strips from two to four inches in width and from five to seven yards in length. Flannel bandages, by reason of the elasticity which they possess, can be applied without reverses, and are used to make a moderate amount of elastic pressure. They are often employed in applying dressings to the head, especially after operations upon the eyes, and are generally applied as a primary roller before the application of the plaster-of-Paris dressing, and may also be used in subacute joint affections, both to protect the parts and make a moderate amount of elastic pressure.

The Rubber Bandage.—This bandage is made from a strip of rubber sheeting from one inch to four inches in width and from three to five yards in length, which, for convenience of application, is rolled into a cylinder. Its use was introduced to the profession by Dr. Martin of Boston, and it will be found a useful form of dressing where it is considered desirable to apply elastic pressure to a part. It may be employed in the treatment of varicose veins of the legs, in chronic ulcers of those parts where pressure is an important element in the treatment, and may be used as a substitute for strapping to secure this object. Its application has also been recommended in the treatment of swelled testicle in that stage of the affection in which pressure is indicated.

Application.—For application to the leg a rubber bandage two and a half inches in width and three yards in length is required. The initial extremity of the roller is fixed upon the foot near the toes and secured by a circular turn; the foot is then covered in by spiral turns overlapping each other about two-thirds, and a figure-of-8 turn is made from the ankle to the instep, and the bandage is then carried up the limb to the knee with spiral turns, where it is secured by two tapes sewed to the terminal extremity of the bandage, which are passed around the leg and tied. The bandage need not be reversed, as its elasticity allows it to conform to the shape of the limb. Care should be taken not to apply the turns with too much firmness; the bandage should be stretched very slightly; if this precaution is not taken, it soon becomes uncomfortable to the patient. A patient using one of these bandages will soon learn to apply it himself, making just the requisite amount of tension to secure its holding its place and to ensure a comfortable amount of pressure upon the part. A well-fitting stocking may be placed upon the limb before the bandage is applied or it may be applied directly to the skin.

The bandage should be removed at night when the patient goes to bed and hung up to dry, as its inner surface becomes moist from the secretions from the skin; it should be reapplied as soon as the patient rises in the morning.

In using it in the treatment of ulcers of the leg no ointments should be applied to the ulcer, as oily dressings soon destroy the rubber; dressings may be made to the ulcer by means of dry powders, such as oxide of zinc, iodoform, or aristol, before the bandage is applied.

In the treatment of swelled testicle the bandage is applied to the testicle by means of recurrent turns not too firmly made, and secured in place by spiral turns until the whole surface of the organ is covered in; the end of the bandage is secured with tapes tied around the root of the scrotum. The same precaution to apply the bandage so as to make only moderate pressure should here also be observed.

Fixed Dressings or Hardening Bandages.

Fixed dressings are prepared from a variety of substances which are incorporated in the meshes of some fabric, such as crinoline or cheesecloth, or painted over its surface to give fixity or solidity to the bandage. The materials most commonly used in the preparation of fixed dressings are plaster of Paris, starch, silicate of sodium or potassium, paraffin, or a mixture of chalk and gum or of oxide of zinc and glue.

Plaster-of-Paris Bandage.—The plaster of Paris used for the preparation of surgical dressings should be of the same quality as that which the dental surgeons employ in taking casts for teeth; that is, the extra-calcined variety. If moist or of inferior quality, it will not set rapidly or firmly and will fail to give sufficient fixation to the dressing. The plaster-of-Paris dressing may be applied in several ways, either by covering the part to be enclosed with some loose fabric and rubbing the plaster of Paris into it, alternating the layers of the fabric with layers of moist plaster, or it may be applied by means of a roller which has been prepared with plaster of Paris and is moistened and applied to the part.

In applying a plaster-of-Paris dressing according to the first method the part to be enclosed—the leg, for instance—should be covered by a neatly-applied flannel bandage or muslin bandage which has been shrunken by being washed; new muslin is not satisfactory as a primary application to a limb in applying a plaster-of-Paris dressing, as the moisture from the plaster wets it and causes it to shrink, so that it may cause injurious pressure after the bandage becomes dry. The limb having been covered by the flannel bandage, and any bony prominences, such as the malleoli, having been padded with small wads of cotton to prevent undue pressure upon them, the parts are then covered by a layer of crinoline bandage or by strips of cheese-cloth or any other loose material. A small quantity of plaster of Paris is next mixed with water until it has the consistence of thick cream, when it is smeared evenly over the whole surface of the previously applied bandage. Another layer of the bandage or of strips is next applied until a casing of the desired thickness is obtained. If the plaster of Paris of the quality previously described be used, it will set or become hard in a few minutes.

The most convenient method of applying a plaster-of-Paris dressing is that employed by Professor Sayre, which consists in the use of bandages which have been previously prepared with plaster of Paris; these are moistened and applied while moist to the parts to be encased.

Preparation of Plaster-of-Paris Bandages.—These bandages are prepared by taking cheese-cloth, mosquito-netting, or crinoline—which latter is by far the best fabric—and tearing or cutting it into strips two and a half to three inches in width and five yards in length. These are laid upon a table and plaster of Paris is dusted over them and rubbed into the meshes of the fabric, and when the material has been thoroughly impregnated with plaster it is loosely rolled into a cylinder; the bandages when prepared should be placed in air-tight cans until required for use.

Plaster-of-Paris bandages which have been exposed to the air or have been kept for a long time are not apt to set well when applied; but if such bandages are placed in a hot oven and baked for a half hour before being used, they will set as satisfactorily as those freshly prepared.

Plaster-of-Paris bandages may be prepared by a machine made for the purpose, but they are not apt to have the plaster as evenly distributed through them, and therefore they are not as satisfactory as those prepared by hand.

Application of the Plaster-of-Paris Bandage.—Before applying the plaster-of-Paris bandage the part to be encased—the leg, for instance—should be covered by a flannel roller, the bony prominences being pro-

tected by pads of cotton, or a closely-fitting stocking may be applied to the part. The bandage, five yards in length, three inches in width, should be dipped in warm water and kept covered by water for a few minutes; it may be squeezed with the hand, and as soon as the bubbles of air cease to escape it is a sign that it is thoroughly soaked and ready for application. On removing it from the water the excess of water should be squeezed out by the hand, and the bandage should be evenly applied to the part with just enough firmness to make it fit the part nicely, and as few reverses as possible should be made. A sufficient number of bandages are applied to make a dressing as firm as may be required; three rollers of the above dimensions are usually quite ample for a dressing for the leg, and when the last roller has been applied, some dry plaster should be moistened with water until it has the consistence of thick cream, and it should then be rubbed evenly over the surface of the bandage to give it a finish (Fig. 68). If a good quality

Fig. 68.

Leg encased in plaster-of-Paris bandage.

of plaster of Paris has been used, the bandage should be quite firm in from ten to fifteen minutes, but the patient should not for a few hours be allowed to put any weight upon the bandage.

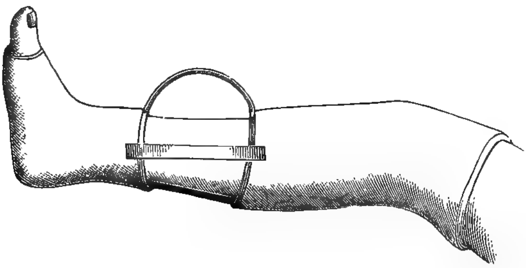
An equally firm dressing may be applied with the use of a less number of bandages if the surgeon rubs over the surface of each layer of bandage applied a little moist plaster of Paris, then applies another layer of bandage, and repeats the same procedure, finishing the dressing by an external coat of moist plaster as above described.

A fewer number of bandages will be required in applying these dressings if narrow strips of tin, zinc, or binder's board are incorporated in the layers of the bandage, and they also increase the strength of the dressing.

Interrupted Plaster-of-Paris Dressing.—This form of plaster-of-Paris dressing is applied by first placing a short iron rod or strip of iron under the part, extending some distance above and below the point at which the dressing is to be interrupted; this is fixed by a few turns above and below the portion of the limb which is to be left exposed; stout wire or strips of iron are next bent into loops, the extremities of which are incorporated in the subsequent turns of the plaster bandage. Three loops thus secured, one on either side and one directly opposite the posterior

iron bar or strip, will usually make the dressing sufficiently firm (Fig. 69). A number of turns of the bandage are applied to firmly fix the

Fig. 69.

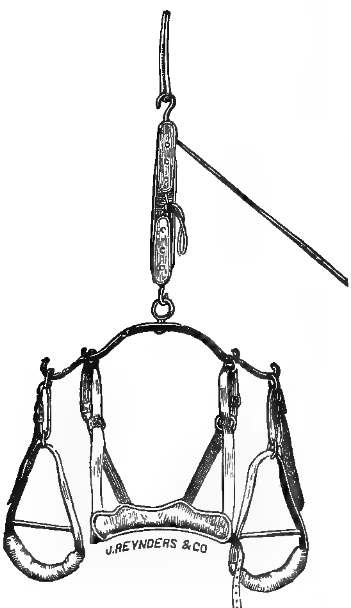


Interrupted plaster-of-Paris dressing (Stimson).

loops, and the limb is held in the desired position until the plaster of Paris has set.

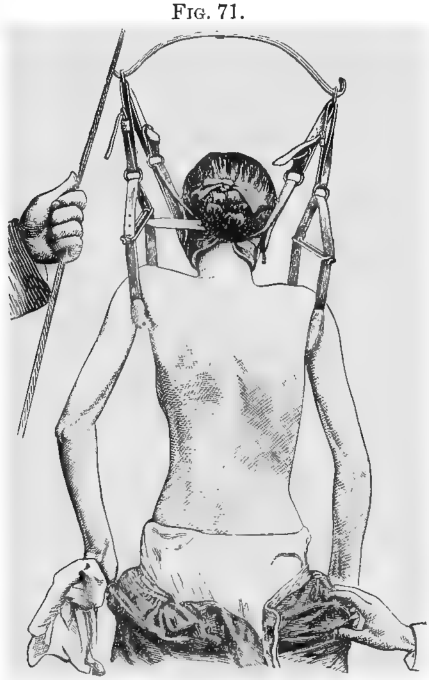
Application of Plaster-of-Paris Jacket.—The patient's body should be covered with a soft, closely-fitting woven seamless shirt without arms,

Fig. 70.



Suspensory apparatus.

Fig. 71.



Patient suspended for application of plaster-of-Paris jacket.

but with shoulder-straps to hold it in position, or an ordinary woven undershirt may be employed; one or two folded towels or a pad of cotton wrapped in a towel is next placed over the abdomen between the

shirt and skin, called by Prof. Sayre the dinner-pad, and is intended to leave space for the distention of the abdomen after eating. Small pads of raw cotton may also be placed over the anterior iliac spines, and in the case of females a pad of cotton wrapped in a handkerchief may be placed over each mammary gland. The patient should next be suspended by the apparatus consisting of a collar and arm-pieces attached to a cross-bar (Fig. 70), which is attached by a cord and pulley to a tripod. If this apparatus is not at hand, a very satisfactory substitute may be made by folding two towels into cravats and tying together the ends so as to make two loops, one of which is placed in each axilla; a bar of wood two and a half feet in length is next taken, and the loops are secured to the ends of this by stout cords or handkerchiefs; a Barton's bandage is next applied to the head, and a strip of bandage is passed under the turns which cross the vertex and secured to the middle of the cross-bar. The bar is next suspended by a cord passed through a pulley or ring which may be attached to the sill of a door if the ordinary tripod cannot be obtained. The patient should be raised by the apparatus until the toes only are in contact with the floor, and the extension should not be carried to the point which makes it uncomfortable to the patient (Fig. 71).

Some surgeons omit making extension in applying plaster-of-Paris bandage, using only the head-gear for extension and omitting the extension from the arm-piece. The shirt should be drawn downward from the hips by an assistant and held in place until a few turns of the bandage have been applied. The plaster bandage having been soaked and squeezed, a turn should be made around the body just above the pelvis; it should then be carried downward, and several turns should be made around the body below the iliac spines, and from this point it should be made to ascend gradually by spiral turns until the axillary line is reached. The turns should be applied smoothly and not too tightly. After two or three layers of turns have been applied the surgeon may rub some moist plaster upon their surface if he desires to use fewer bandages. These turns are repeated until a bandage of the desired thickness is applied, and the surface of the dressing may be finished by rubbing it over with moistened plaster. The jacket for a child will usually require about three or four bandages of the dimensions given; for an adult six or eight bandages will be required.

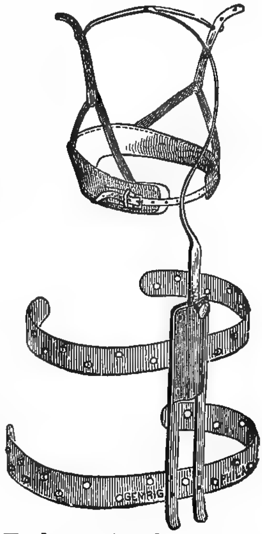
The patient should be kept suspended until the bandage has set, usually from ten to fifteen minutes, and then should be carefully lifted, so as not to bend the spine, and placed on his back upon a mattress until the dressing becomes perfectly hard. The dinner-pad (and mammary pads, if they have been used) should next be removed. In applying this dressing strips of zinc or tin may be placed between the layers of bandage if it is desired to give more strength to the jacket. Great care must be exercised lest too much extension is applied and a serious accident occur.

Application of Jury-mast by means of Plaster of Paris.—In disease of the spine involving the cervical and upper dorsal region an ordinary plaster-of-Paris jacket is not satisfactory, and in such cases the jury-mast is employed in connection with the plaster jacket. In applying the jury-mast the same steps are taken in the preparation of the patient

as in applying the plaster-of-Paris jacket, with the exception of extension, which need not be used.

After the application of three or four layers of the plaster-of-Paris bandage to the body an apparatus made of two bars of metal having two perforated strips of zinc attached to them a few inches apart, which partly encircle the body, is applied and held in position by turns of the plaster bandage. The perpendicular bars have at their upper part a slot into which the lower end of the jury-mast fits and is secured by a screw; to the upper part of this is attached a movable cross-bar, attached to which are fastened the straps of the collar from which the head is suspended (Fig. 72).

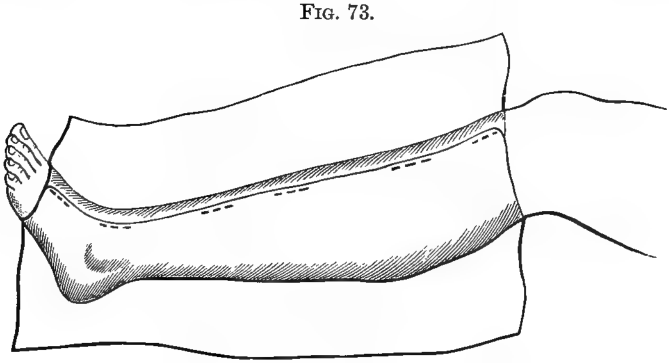
FIG. 72.



Head-support and jury-mast.

The Bavarian Dressing.—In applying this dressing, which is sometimes employed in the treatment of fractures, take two pieces of canton flannel the length of the part to be enclosed and more than wide enough to envelop its circumference. In applying this dressing to the leg these pieces should be cut so as to correspond to the outline of the leg and posterior portion of the foot. These pieces should be placed one over the other, and sewed together in the middle line, the seam corresponding to the back of the leg. The leg and foot are then placed upon this, and the inner layer of flannel is brought up in front of the leg and over the dorsum of the foot and made fast with pins or strips (Fig. 73). Plaster of Paris is next mixed with water and made

FIG. 73.



Bavarian dressing.

into a paste, which is rubbed thickly over the flannel next to the surface of the limb until a sufficient thickness is obtained; the outer layer of flannel is then brought up about the leg and moulded to its surface by the hands. A loosely-applied bandage may now be used to hold the dressing in place until the plaster has set.

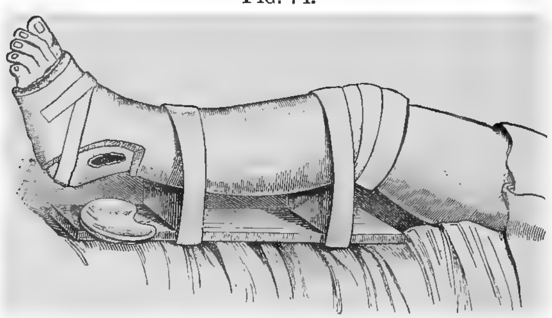
When it is necessary to inspect the parts the turns of the bandage

are cut, and upon separating the layers of flannel the two halves can be turned aside, the seam at the back acting as a hinge. Upon reapplying the splints to the leg the dressing may be retained in position by a bandage or by one or two strips of muslin.

Moulded Plaster Splints.—It is sometimes found difficult to apply the ordinary plaster dressing to parts irregular in shape, and at the same time to have a splint which can be removed with ease. To accomplish this purpose moulded splints of plaster may be made by cutting a paper pattern of the part to be covered in, and then cutting pieces of crinoline to conform to this pattern; eight or ten pieces will usually form a splint of sufficient thickness. One of these pieces of crinoline is laid upon a table and dry plaster is rubbed into its meshes; another is laid upon this and plaster is applied to it in the same way; and so on until all the pieces have been placed in position, one over the other, with plaster rubbed well into the meshes. The dressing is then folded up and dipped into water, squeezed out, and moulded to the part and held in position, by the turns of a bandage, until it sets. The edges should slightly overlap each other, and in applying it a strip of waxed paper may be placed under the overlapping edges to prevent its adhesion to the surface below, and this facilitates its removal. Splints prepared in this way can be removed with ease, and are often of service in cases where it is desirable to inspect the parts frequently. The author has employed with advantage such splints in making fixation of the hip-joint in cases of coxalgia, and also for the same purpose in affections of other joints. Splints upon being reapplied are secured by a few strips of bandage or by a roller bandage.

Trapping Plaster-of-Paris Bandages.—It is often necessary to make a trap or fenestrum in the plaster-of-Paris bandage which has been applied to a part where there is a wound which requires inspection or dressing. In applying the bandage it is well to make some provision whereby the plaster-of-Paris dressing over the seat of the wound may be cut away. To accomplish this, before applying a plaster-of-Paris bandage a compress of lint or gauze should be placed over the wound, which, when the

FIG. 74.



Plaster-of-Paris bandage trapped (Esmarch).

dressing is completed, forms a projection on its surface indicating the position of the wound, and also allows the surgeon to cut away the plaster dressing without injury to the skin below (Fig. 74). These traps

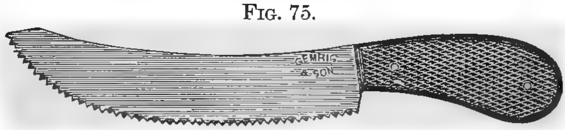
may be cut out with a knife after the bandage has partially set or after it has become hard. In applying a plaster-of-Paris dressing in cases of compound fracture and after osteotomy it is always well to make provision for trapping the bandage if it should become necessary, although in the vast majority of cases it does not need to be done.

Removing Plaster-of-Paris from the Hands.—One objection to the use of plaster-of-Paris dressings is the difficulty of removing the plaster from the hands of the surgeon, and the harsh condition in which the skin of the hand is left after its removal. If, however, the hands are washed in a solution of carbonate of sodium—a tablespoonful to a basin of water—the plaster will be readily removed, and the skin will be left in a soft and comfortable condition.

Removal of the Plaster-of-Paris Bandage.—The removal of the plaster-of-Paris bandage is sometimes a matter of difficulty, particularly if it has to be removed before the parts below have become consolidated, as it may disarrange them and cause the patient pain if it is not accomplished without much force.

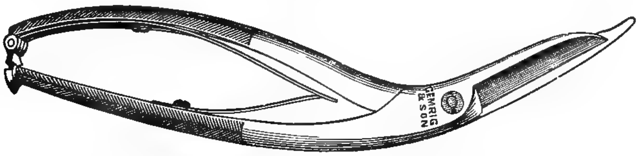
When the bandage is applied to get a cast of the part, or in the treatment of fractures where it may be desirable to remove it within a few days, a strip of sheet lead one inch in width is first placed over the flannel bandage, and is allowed to project at each end beyond the dressing; after the plaster bandage has been applied and before it has quite set it can be readily cut through upon this strip with a knife without injury to the parts below, and the cast can be removed as soon as it is firm. It may also be removed by means of a saw devised for this purpose (Fig. 75), or by strong cutting shears of various kinds (Fig. 76), or a line may be painted over the dressing with hydrochloric acid or vinegar, which softens the plaster so that it can be readily cut through with a knife. Dr. William B. Hopkins has devised a vertebrated metal chain which is applied to the part before the plaster is applied, and removed when the bandage has set, leaving a hollow longitudinal ridge which can be cut through or divided with a rasp. The use of the saw or shears is the most satisfactory method to remove these dressings; the only caution to be exercised is to use them carefully as the final layers of the bandage are divided, to avoid wounding the skin.

FIG. 75.



Saw for removing plaster-of-Paris bandage.

FIG. 76.



Shears for cutting plaster-of-Paris bandage.

Uses of the Plaster-of-Paris Dressings.—Plaster-of-Paris dressings are employed to secure fixation, as primary or secondary dressings in the treatment of fractures, and for a like purpose in injuries or diseases of the joints. They are also largely used in the treatment of diseases of the spinal column, and will also be found the most satisfactory dressing after osteotomy and tenotomy to secure immobility and hold the parts in their corrected positions; when employed in the dressings of cases after tenotomy they are generally used for a few weeks until the proper mechanical apparatus is applied.

The Starched Bandage.—In the application of this bandage starch is first mixed with water until a thick creamy mixture results; to this is added boiling water until a clear mucilaginous liquid is produced; if too thin, it can be made thicker by heating for a few minutes. The part to be dressed is first covered with a flannel roller, and over this a few layers of cheese-cloth or crinoline, which has been shrunken, are applied: the starch is then smeared or rubbed with the hand evenly into the meshes of the material, and the part is again covered with a layer of turns of the bandage, and the starch is again applied; this manipulation is continued until a dressing of the desired thickness is produced. Strips of pasteboard may be applied between the layers of the bandage to give additional strength to the dressing if desired. It requires from twenty-four to thirty-six hours for the starched bandage to become dry and thoroughly set, which is a decided disadvantage in its employment.

A starched bandage may be removed in the same way in which the plaster-of-Paris dressing is removed. Before the introduction of the plaster-of-Paris dressing the starched bandage was much employed as a means of fixation in the treatment of fractures and injuries of the joints. It may be used in such cases, but possesses no advantage over the former dressing, and has the disadvantage of setting much less promptly.

Gum-and-chalk Bandage.—In the application of this dressing equal parts of powdered gum arabic and precipitated chalk are mixed with boiling water until a mass of the consistence of thick cream results. This is applied to the cheese-cloth or crinoline bandage in the same manner as the starch in the application of the starched bandage: it has the advantage over the latter dressing of setting more promptly, five or six hours only being required for it to become hard. It may be employed for the same purpose as the starched or plaster-of Paris bandage.

Silicate-of-Potassium or Sodium Bandage.—In the application of this bandage, after the flannel roller and several layers of cheese-cloth or crinoline bandage have been applied to the part, the surface of the latter is coated with silicate of sodium or potassium applied by means of a brush; then a second layer of crinoline bandage is applied and treated in the same manner, and this manipulation is continued until a bandage of the desired thickness is produced. It requires twenty-four hours for this dressing to become firm. In removing the silicate bandage it may be first softened by soaking it in warm water, and it then can be readily cut with scissors.

In applying either the starched bandage or the silicate-of-potassium bandage care should be taken to use cheese-cloth or crinoline which has been shrunken by being moistened and allowed to dry before being em-

ployed; otherwise dangerous compression of the part may occur if the bandage has been firmly applied and shrinks after its application.

The Paraffin Bandage.—Paraffin, which melts at from 105° to 120° F., is employed in the application of a fixed dressing. The limb being covered by a flannel roller, a vessel containing paraffin is placed in a basin of boiling water; as the bandage, which may be either of flannel, cheese-cloth, or crinoline, is unwound, it is passed through the melted paraffin and applied to the part, and the turns are repeated until a dressing of sufficient thickness results, and the surface may be brushed over with melted paraffin. This dressing sets very rapidly, being quite firm in from five to ten minutes. It possesses the advantage over the other fixed dressings in that it does not absorb discharges and become offensive, and for this reason it was formerly recommended in the formation of a fixation splint in the treatment of compound fractures.

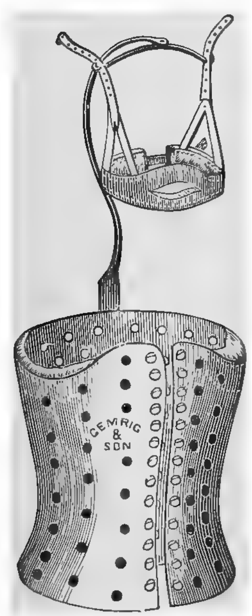
Glue or Glue-and-Oxide-of-zinc Bandages.—Glue or glue combined with oxide of zinc has been employed in the preparation of fixed dressings, but possesses no advantage over those previously mentioned.

In the application of this bandage glue which has been dissolved in boiling water is brushed over the surface of a crinoline roller applied to the part, or there may be added to the solution of glue oxide of zinc. The glue bandage becomes hard more promptly than the starched bandage, but does not form so strong a dressing as the starched, silicate-of-sodium, or plaster-of-Paris bandage.

Raw-hide or Leather Splints for Dressings.

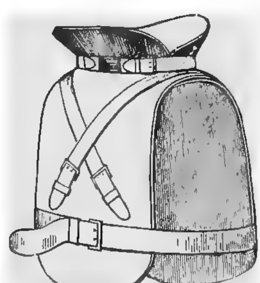
In applying raw-hide or leather splints it is necessary first to apply a plaster-of-Paris bandage to the part to which the raw-hide dressing is fitted, and as soon as the plaster has set it is removed, and a solid plaster cast is next made by pouring liquid plaster-of-Paris into the mould thus obtained. When this has become dry a piece of raw-hide, which has been soaked for some hours in warm water, is moulded to the cast, and is firmly held in contact with it by means of a bandage or by tacks until it has become perfectly dry, which

Fig. 77.



Leather jacket with jury-mast.

Fig. 78.



Leather splint for cervical caries (Owen).

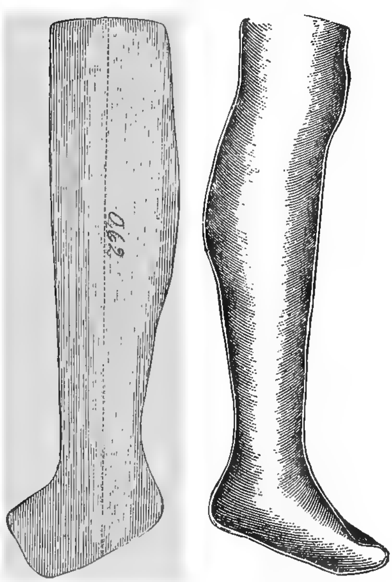
usually requires several days. It is then removed, and its surface is covered with several coats of shellac to prevent its absorbing moisture from the skin when applied and changing its shape. Eyelets or hooks are fastened to the edges of the splints, through which strings are passed to secure it in place.

Raw-hide splints prepared in this manner fit the part very accurately and constitute a very satisfactory dressing for cases of joint disease, and in the form of leather jackets are often employed in the treatment of disease of the spine in place of the plaster-of-Paris jacket (Figs. 77, 78).

Binder's-board or Pasteboard Splints.—Binder's board, which can be obtained in sheets of different thickness, is frequently employed for the manufacture of splints. A portion of board of the requisite size and thickness is dipped in boiling water for a short time, and when it has become softened it is removed and allowed to cool; a thick layer of cotton batting is next applied over it, and it is then moulded to the part and held firmly in place by the turns of a roller bandage; in a few hours it becomes dry and hard.

This material, from its cheapness and the ease with which it is obtained, is frequently employed to mould splints for the treatment of fractures, especially in children, and for the fixation of joints in the treatment of acute and chronic joint affections (Fig. 79). A moulded binder's-board splint is often employed to fix the ends of the bones after the excision of a joint.

Fig. 79.



Moulded binder's-board splints.

Porous Felt Splints.—This material is also employed for the manufacture of splints, and is applied by dipping the material in hot water and then moulding it to the part; as it dries it becomes hard.

Hatter's-felt Splints. — Hatter's felt is sometimes employed for the manufacture of splints or dressings. It is softened by dipping it in boiling water or heating it in the flame of an alcohol lamp, and when soft and pliable it is moulded to the part, and as it cools it again becomes hard.

Gutta-percha Splints.—These splints or dressings are made from sheets of gutta-percha from one-sixteenth to one-eighth of an inch in thickness. This material is cut into the requisite shape, and is prepared for moulding by immersing it in hot water, when it becomes soft and can be moulded to the surface. Care should be taken that it is not allowed to become too soft, by too long immersion, to permit its being conveniently handled.

Materials Used in Surgical Dressings.

Lint.—This material is employed in surgical dressings, and is of two varieties—the domestic lint, which consists of pieces of old linen or muslin which have been thoroughly washed or boiled and then dried, or the surgical lint, which is manufactured by machinery and resembles canton flannel in appearance; the latter is the best material, as it has a greater absorbing capacity.

Lint is used as a material on which unctuous preparations are spread in the dressings of wounds, and is also employed as a material for saturating with the various solutions which are used in wet dressings, such as lead-water and laudanum, or dilute alcohol. The lint, after being saturated with these solutions, may be covered with rubber tissue or oiled silk when applied, to prevent too rapid evaporation of the solution. It is also one of the best materials from which to construct compresses employed in the treatment of fractures, to control hemorrhage, or to make pressure for any purpose.

Paper Lint.—*Paper lint*, made from wood-pulp, is also employed in surgical dressings, as it has great absorbing power for fluids, and it may be used as a substitute for surgical lint in the application of wet dressings.

Oakum.—Oakum, which is made from old tarred rope, was formerly much employed for dressing of wounds before the introduction of the antiseptic method of wound-treatment. From its elasticity it is found to be an excellent material for padding splints or other surgical appliances. It is also employed in the form of pads to place under patients to relieve portions of the body from pressure or to absorb discharges which soak through the dressings. A mass of oakum which has been well teased out and wrapped in a towel forms an excellent pillow on which to support a stump.

The *oakum seton* is highly recommended by Dr. Sayre as a means of making a direct application of dressings to sinuses of bone: the oakum is loosely twisted into a cord and covered with any ointment desired, and is passed through the sinuses in the bone; the position of the seton is changed from time to time, fresh ointment being applied before it is drawn through.

Cotton.—Cotton is now employed in surgical dressings, principally as a material to pad splints or to relieve salient parts of the skeleton from pressure in the application of splints or bandages; for instance, in the application of plaster-of-Paris bandages the bony prominences are generally covered by small masses of cotton; it possesses but little absorbent power unless used in the form of absorbent cotton, and is not much employed in surgical dressings except for the purposes mentioned above.

Absorbent Cotton.—This material is prepared from ordinary cotton, which is boiled with a strong alkali to remove the oily matter which it contains. When so prepared it absorbs liquids freely, and for this reason is largely employed in surgical dressings. A small mass of absorbent cotton wrapped on the end of a probe or stick is now generally employed to make applications to wounds, and has taken the place of the sponge or brush which was formerly employed for this purpose. From its cheapness, after one application it can be thrown away and a new piece

can be used, and thus the danger of carrying infection from one wound to another by the applicator is abolished. It is largely employed in gynecological practice for making applications to the female genital organs.

When impregnated with various antiseptic substances, such as bichloride of mercury, carbolic acid, boric acid, and salicylic acid, absorbent cotton forms the bichloride, carbolized, borated, and salicylated cotton so much used in antiseptic dressings.

Jute.—This substance is made from the fabric of the *Corchorus capsularis*, which, on account of the character of its fibre, possesses both elasticity and absorbent qualities: it has been employed for much the same purposes as oakum and cotton, such as the padding of splints, and is also used as an external absorbent dressing.

Wood-wool.—Wood-wool, made from wood-pulp, such as is employed in the manufacture of paper, is also furnished in the shape of lint, sponges, and pads, and may be used for the same purposes in surgical dressings, in place of surgical lint or the ordinary sponges or pads.

Oiled Silk and Muslin.—These materials are employed as an external covering for moist dressings to prevent rapid evaporation from the dressings; they form excellent materials for this purpose, but, as they are quite expensive, their use is limited.

Waxed or Paraffin Paper.—This dressing is prepared by passing sheets of tissue-paper through melted wax or paraffin, and then allowing them to dry for a few minutes. Paper thus treated forms an excellent and cheap substitute for oiled silk and oiled muslin, and may be employed for the same purposes for which these materials are used.

Rubber Tissue.—This material consists of rubber run out into very thin sheets; it has a glazed surface, is very pliable and strong, and forms a cheap and satisfactory substitute for oiled silk, being employed for the same purposes. In the moist method of antiseptic dressing it may be used in place of the macintosh.

Parchment Paper.—This is a very tough paper material which can be soaked in a solution of corrosive sublimate or carbolic acid without becoming so much softened as to tear upon handling, and it is employed for the same purposes as macintosh.

Protective.—Protective is employed to prevent the wound from being irritated by antiseptic substances with which the gauze is impregnated or by its irregular surface. Various materials are employed as protectives, the principal requirement being that the tissue can be readily rendered aseptic and does not absorb any irritating materials from the dressings. The protective first employed by Lister, which is still generally used, is prepared by coating oiled silk with copal varnish, and when this is dry a mixture of 1 part of dextrin, two parts of powdered starch, and 16 parts of a 1 : 20 carbolic solution is rubbed over its surface. Rubber tissue may be employed very satisfactorily as a substitute for this protective.

Macintosh.—This consists of cotton cloth with a thin layer of india-rubber spread on one side. It is employed in antiseptic dressings as a layer outside of the gauze, and should be applied with the rubber surface toward the wound, to prevent the entrance of air, and to allow the serum from the wound to permeate the gauze and not to soak directly through the dressings.

Rubber Dam.—This is a thin pure rubber tissue, and, as it has no cloth surface like macintosh, it is cleaned and sterilized with greater facility. It is used in applying the moist method of dressing to cover the gauze dressings, and is attached to a drainage-tube in abdominal wounds to shut off the opening of the drainage-tube from the abdominal wound. Before being used it should be washed with soap and water and rinsed, and then placed in a solution of carbolic acid for a short time.

Gauze Dressings.—The most convenient and cheapest material for wound-dressing is a sheer material known to the trade as cheese- or tobacco-cloth. By reason of having a very open mesh it absorbs well either the materials with which it is prepared or the discharges from the wound. It can be readily obtained anywhere, is inexpensive, and is soft and pliable, so that it is a comfortable dressing to the patient.

In the preparation of cheese-cloth to form the gauze dressings it is first placed in a vessel and covered with water, to which is added washing soda or lye, and is boiled; the soda or lye is added to remove any oily matters which the cheese-cloth contains, thus making it more absorbent. After the cheese-cloth has been boiled it is washed and passed through a clothes-wringer, and is then impregnated with some of the various substances which are used to render it antiseptic, or it may be dried and baked in an oven and be used as the simple sterilized gauze.

Compresses.—Compresses are prepared by folding pieces of linen or flannel upon themselves, so as to form masses of various sizes; oakum or cotton may also be used for compresses. Compresses are employed to make pressure over localized portions of the body, as in the treatment of fractures, or to make pressure on vessels for the control of hemorrhage.

Tampon.—A tampon is a form of compress which is employed in cavities to make pressure, to control hemorrhage, or to apply various medicines to the surface of a cavity. Tampons made to control hemorrhage are generally made of strips of bichloride or iodoform gauze or of pledgets of bichloride cotton. In applying this the strips of cotton are packed into the cavity, and when the cavity is full a compress is applied superficially and held in place by a bandage.

A *glycerin tampon*, employed as an application to the os uteri, may be made by pouring half an ounce of glycerin on a piece of cotton or wool and then turning up the ends and securing them by a string, one end of which is allowed to remain long to hang from the vagina to facilitate its removal.

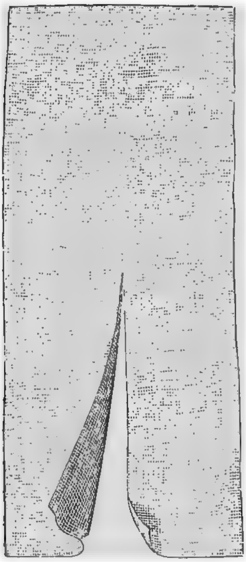
Tent.—This consists of a small portion of lint, oakum, or muslin rolled into a conical shape, and is employed to keep wounds open and to facilitate the escape of discharges. This dressing is not much employed at the present time, its use being largely superseded by the drainage-tube.

Retractors.—Retractors are made by taking a piece of muslin four inches wide and twelve to eighteen inches in length, and splitting it as far as the centre, thus making a two-tailed retractor (Fig. 80). A three-tailed retractor is made by making two splits in the fabric (Fig. 81).

Plasters.—The varieties of plasters which are most commonly employed in surgical dressings are *adhesive* or *resin* plaster, *isinglass* plaster, *rubber adhesive* plaster, and *soap* plaster.

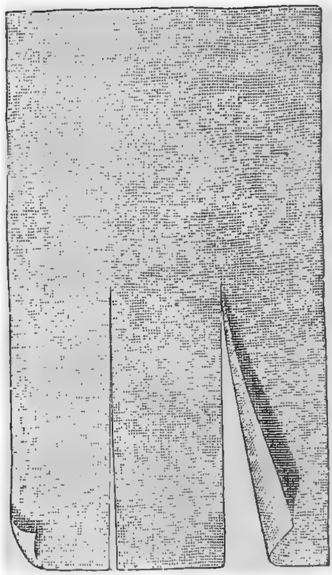
Resin Plaster.—This plaster, which is machine-spread, is one of the most widely-employed plasters in surgical dressings: the spread surface is covered with a layer of tissue-paper, which should be removed before

Fig. 80.



Two-tailed retractor.

Fig. 81.



Three-tailed retractor.

it is used, and the strips should be cut lengthwise from the roll, as the cloth upon which it is spread stretches more transversely than in a longitudinal direction. When heated and applied to the surface it holds firmly; it is prepared for application by applying the unspread side to a vessel containing hot water, or it may be passed rapidly through the flame of an alcohol lamp.

This is the plaster generally used in making the extension apparatus for the treatment of fractures, for strapping the chest in fractures of the ribs and sternum, for strapping the pelvis in cases of fractures of the pelvic bones, or for strapping the breast, the testicle, ulcers, or joints.

Rubber Adhesive Plaster.—This plaster is made by spreading a preparation of india-rubber on muslin, and has the advantage over the ordinary resin plaster that it adheres without the application of heat. It is employed for the same purposes as resin plaster, but when applied continuously to the skin it is apt to produce a certain amount of irritation, and for this reason, when it is to be applied for some time, as in the case of an extension apparatus, it is not so comfortable a dressing as that made from resin plaster.

Isinglass Plaster.—This plaster, which is made by spreading a solution of isinglass upon silk or muslin, will be found the most useful dressing in the treatment of superficial wounds. It is made to adhere to the surface by moistening it, and when used in the treatment of wounds it should be moistened with an antiseptic solution: it is in this way ren-

dered aseptic, and may be used with safety in connection with other aseptic dressings. The best form of this plaster is spread on muslin, and when properly applied adheres as firmly and possesses as much strength as the ordinary resin plaster.

Before using any of these plasters, if the part to which they are to be applied contains hairs, these should be shaved off, otherwise traction upon these, if the plaster is used for the purpose of extension, or in its removal, will cause the patient discomfort or pain.

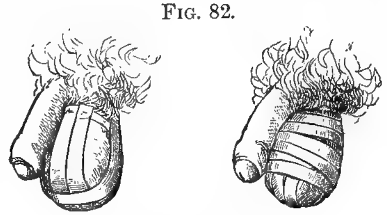
Soap Plaster.—This plaster for surgical purposes is prepared by spreading *emplastrum saponis* upon kid or chamois. It has little adhesive power, and is used simply to give support to parts or to protect salient portions of the skeleton from pressure. It is found a most useful dressing when applied over the sacrum in cases of threatened bed-sores, and may be applied for the same purpose to other parts of the body where pressure-sores are apt to occur.

In the treatment of joints a well-moulded soap-plaster splint secured by a bandage will often be found a most efficient dressing, and in the treatment of fractures the comfort of the patient is often materially increased by applying a piece of soap plaster over the bony prominences, upon which the splints, even when well padded, are apt to make an undue amount of pressure.

Strapping.—The application of pressure to parts by means of strips of plaster firmly applied is a procedure often employed in surgical practice.

Strapping the Testicle.—In strapping the testicle strips of resin plaster are usually employed; a dozen or more strips, three-quarters of an inch in width and twelve inches in length, will be required. The scrotum should be first washed and shaved, and the surgeon then draws the skin over the affected organ tense by passing the thumb and finger around the scrotum at its upper portion, making circular constriction. A strip of plaster which has been heated is passed in a circular manner around the skin of the scrotum above the organ, and is tightly drawn and secured; this isolates the part and prevents the other strips from slipping. Strips are now employed in a longitudinal direction, the first strip being fastened to the circular strip and carried over the most prominent portion of the testicle (Fig. 82), and is then carried back to the circular strip and fastened. A number of these strips are applied in an imbricated manner until the skin is covered in (Fig. 82), and the dressing is completed by passing transverse strips around the scrotum from its lowest portion to the circular strip; care should be taken to see that no portion of the skin is left uncovered.

Fig. 82.

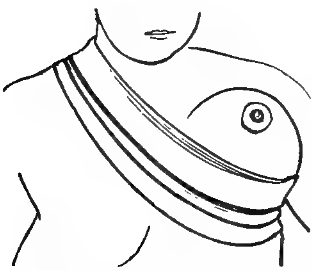


Strapping the testicle (Smith).

Strapping the testicle is employed with advantage in the subacute stage of orchitis or epididymitis, and is a useful means of applying pressure to the scrotum after the injection treatment of hydrocele. As the swelling of the testicle diminishes the strips become loose and the parts require restrapping.

Strapping the Breast.—In strapping the breast, strips of resin plaster, two inches in width and long enough to pass from the opposite shoulder under the breast to the point of starting, are required. In applying it the end of the strip is placed on the spine of the scapula on the side opposite the diseased breast, is carried forward over the shoulder and obliquely downward under the breast and axilla, and then over the back to the point of starting; the next strip is applied in the same direction, overlapping about one-third of the previous strip (Fig. 83); these oblique strips are applied in an imbricated manner until a sufficient number have been used to cover in the breast, or the oblique strips may be alternated with circular strips passing from the sternum over the breast to the spine. A sufficient number of strips are used to cover the breast and make firm compression upon it.

FIG. 83.

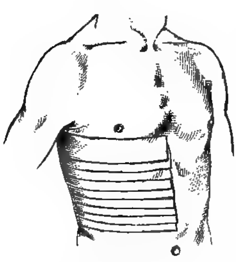


Strapping the breast (Smith).

Strapping the breast in this manner will be found a satisfactory method of treatment in chronic inflammatory conditions of the breast, where it is of advantage to support the breast and make compression at the same time; it has the advantage over the use of a bandage to support and compress the breast in that it does not interfere with the chest motions upon the opposite side of the body.

Strapping the Chest.—To strap one-half of the chest strips of resin plaster, two and a half inches in width and long enough to extend from the spine to the median line of the sternum—eighteen to twenty inches in length—will be required. One extremity of a strip is placed upon the spine opposite the lower portion of the chest; it is then carried over the chest, and its other extremity is fixed upon the skin in the median line of the sternum. Strips are next applied from below upward in the same manner, each strip overlapping one-third of the preceding one, until the axillary fold is reached (Fig. 84); a second layer of strips may be applied over the first if additional fixation is desired, or a few oblique strips may also be employed. Adhesive strips applied in this manner very materially limit the motion of the chest-wall upon the affected side, and are frequently employed in the treatment of fractures and dislocations of the ribs, in contusions of the chest, and in cases of plastic pleurisy where the motions of the chest-walls are extremely painful to the patient.

FIG. 84.

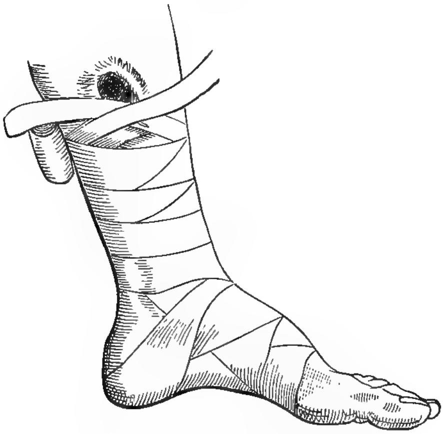


Strapping the chest.

Strapping of Ulcers.—To strap ulcers of the leg, strips of resin plaster, two inches wide and long enough to extend two-thirds around the limb, are required. The ulcer should be thoroughly cleansed and the skin surrounding it should be well dried: the first strip, being heated, is applied obliquely to the long axis of the leg about two inches below the ulcer, and is carried two-thirds around the limb; another strip is applied to a corresponding point of the skin on the opposite

side of the limb and is carried obliquely over the limb, crossing the first strip in the median line, and is carried two-thirds of the way around the leg; alternate strips are then applied until the ulcer is covered in, and the strips are carried several inches above the ulcer (Fig. 85). Care should be taken that the strips are so applied as

Fig. 85.



Strapping ulcer of leg (Liston).

not to meet or cover the entire circumference of the limb, as by so doing injurious circular compression may result. Chronic ulcers upon other portions of the body may be strapped in the same manner.

The strapping of leg ulcers is usually reinforced by the application of a spiral reversed or spica bandage of the lower extremity. Strapping of ulcers of the leg in the manner described will be found a most satisfactory method of treating chronic ulcers in this location in patients who have to work during the course of treatment: the strips need only be removed at intervals of a week, and, if well applied, the dressing is generally a comfortable one to the patient.

Strapping of Joints.—Strips of resin plaster, two inches in width and long enough to extend two-thirds around the joint, are required. The first strip is applied about two inches below the joint, and strips are then applied above this, each strip covering in two-thirds of the preceding one until the joint is covered in and the strips extend a few inches above the joint.

The ankle-joint is strapped by taking strips of resin plaster one and a half inches in width: the first strip is placed over the heel, and its ends are brought forward until they meet over the dorsum of the foot; a second strip encircles the foot and secures the ends of the first strip. The strips are alternately applied, each strip covering one-half of the previous strip until the foot and ankle are covered.

Strapping of joints will be found a satisfactory dressing in the treatment of sprains of joints in their chronic state.

Strapping of a Carbuncle.—To strap a carbuncle strips of resin plaster one to one and a half inches in width are required. These strips are

applied to the margin of the swelling, and are laid on concentrically until all except the central portion are covered in; if a number of openings exist, the strips are so placed as not to cover these. Strapping applied in this manner in the treatment of carbuncle is often a comfortable dressing to the patient, and at the same time the concentric pressure favors the extrusion of the sloughs.

Poultices.—This form of dressing was formerly much employed in the treatment of local inflammatory conditions, or in wounds, as a means of applying heat and moisture to the part at the same time, and, although the use of poultices is now very much restricted since the introduction of the antiseptic method of wound-treatment, there are still conditions in which their employment is both useful and judicious.

Poultices are often employed with advantage in inflammatory affections of the chest and abdominal organs; and in inflammatory affections of the joints and of bone their action, combined with rest, is often most satisfactory; in cases of gangrene their employment hastens the separation of the sloughs. They constitute a form of dressing which conduces much to the comfort of the patient in cases of deep suppuration by their relaxing effect upon the tissues, and their previous use does not prevent the surgeon from using all antiseptic precautions in the opening and drainage of these abscesses and the employment of antiseptic dressings in their subsequent treatment.

Flaxseed Poultice.—This poultice is prepared by adding a little warm water to ground flaxseed, and then adding boiling water and stirring it until the resulting mixture is of the consistency of thick mush. A piece of muslin is next taken, which is cut a little larger than the intended poultice, and this is laid upon the surface of a table, and the poultice mass is spread evenly upon it from a quarter to a half inch in thickness with a spatula or knife; a margin of the muslin of one and a half inches is left, which is turned over after the poultice is spread, and serves to prevent it from escaping around the edges when applied. The surface of the poultice may be evenly spread over with a little olive oil or may be covered with a layer of thin gauze to prevent the mass from adhering to the skin. It is next applied to the surface of the skin, and is covered with a piece of oiled silk, rubber tissue, or waxed paper, and is held in position by a bandage or a binder.

Bread Poultice.—This poultice is prepared from stale wheaten bread, the crusts being discarded and the crumbs only being used; this is moistened with boiling water and allowed to soak for a few moments, when the excessive moisture is poured off and the mass is spread upon a piece of muslin or linen, as before described.

Starch Poultice.—This poultice is prepared by mixing starch with cold water until a smooth, creamy fluid results; boiling water is then added, and it is heated until it becomes clear and it has about the same consistency as the starch used for laundry purposes. When sufficiently cold it is spread upon muslin and applied to the part, and covered with oiled silk or waxed paper. This variety of poultice is principally used in cases of disease of the skin, especially those of the scalp accompanied by the formation of scales or crusts, to facilitate their removal and to furnish a clean surface for the application of ointments or wet dressings.

Charcoal Poultice.—In preparing this poultice flaxseed meal and

powdered charcoal are mixed together, and by adding boiling water a poultice mass is produced which is spread upon muslin as previously detailed. It is better to use animal charcoal in making this poultice, as it has greater deodorizing power than the vegetable charcoal. This poultice is used as an application to gangrenous parts, as it possesses marked deodorizing properties.

Fermenting Poultice.—This poultice may be prepared by adding yeast, two tablespoonfuls, to a mixture of flaxseed with hot water, making a thin poultice mass, and allowing it to stand for a few hours in a warm place; it rises and becomes light, and is then spread upon muslin and applied as required. A few ounces of porter or a piece of yeast-cake may be used as a substitute for the yeast in preparing this poultice; charcoal may also be added to it to increase its disinfectant power. This poultice was formerly, and is still, used as an application to gangrenous parts to hasten their separation and to diminish the odor arising from the necrosed tissues.

Oakum Poultice.—This poultice is prepared by soaking a mass of loosely-picked oakum in hot water, wringing it out, and covering it with a layer of cheese-cloth or antiseptic gauze. It is next applied to the part and covered with oiled silk or rubber tissue, and held in place by a bandage; it has a large capacity for the absorption of discharges. It may be wrung out in a warm bichloride or carbolic solution, and thus form an *antiseptic poultice.*

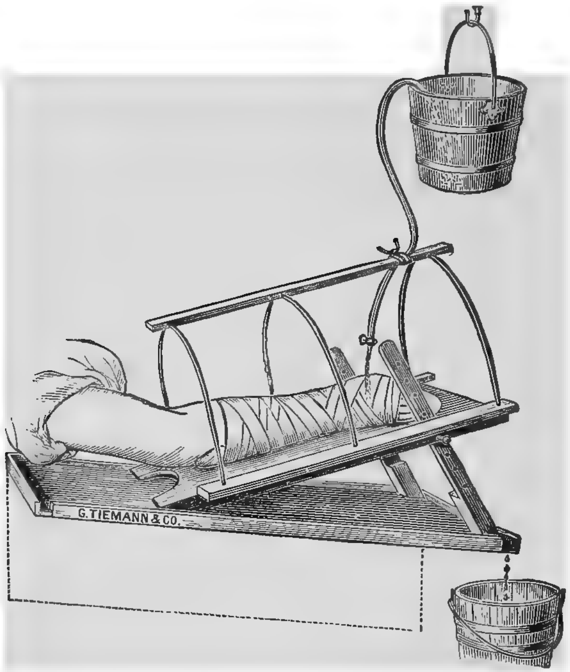
Hot Fomentations.—Hot fomentations are employed to keep up the vitality of parts which have been subjected to injury, as seen in severe contusions or lacerations resulting from railway or machinery accidents; also to combat inflammatory action. Flannel cloths, several layers in thickness, or surgical lint, should be soaked in water having a temperature of 120° F.; these are wrung out and placed over the part and covered with waxed paper or rubber tissue; a second cloth should be placed in hot water, ready to apply as soon as the first-applied cloth begins to cool, and so by continuously reapplying them the part is kept constantly covered by a hot dressing. The use of these hot fomentations may in many cases have to be continued for hours before the desired result is obtained. *Hot compresses* applied in this manner are frequently employed in treating inflammatory conditions of the eye, and are also of the greatest service in keeping up the vitality of parts which have been subjected to severe injury interfering with their blood-supply. The writer has frequently seen contused limbs, which were cold and seemed to be doomed to gangrene by reason of their diminished blood-supply, have their temperature and circulation restored by the patient and persistent use of this dressing. After the vitality of such a part is restored it should be covered with cotton and a flannel bandage and surrounded by hot-water bags or hot-water cans.

Irrigation.—This may be accomplished by allowing the irrigating fluid to come directly in contact with the wound or inflamed part, which is known as *immediate irrigation*, or by allowing the cold or warm fluid to pass through rubber tubes which are in contact with or surround the part; the latter method is known as *mediate irrigation.*

Immediate Irrigation.—In applying immediate irrigation in the treatment of wounds or in inflammatory conditions a funnel-shaped can with

a stop-cock at the bottom, or a bucket, is suspended over the part at a distance of a few inches (Fig. 86), or a jar with a skein of thread or

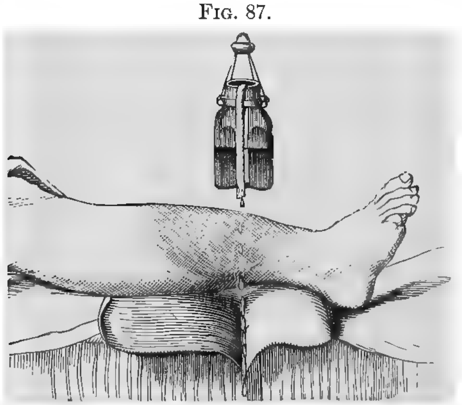
FIG. 86.



Apparatus for continuous irrigation (Esmarch).

lamp-wick arranged to act as a siphon may be employed (Fig. 87). The can or jar is filled with water, and this is allowed to fall, drop by drop,

FIG. 87.



Irrigating apparatus (Erichsen).

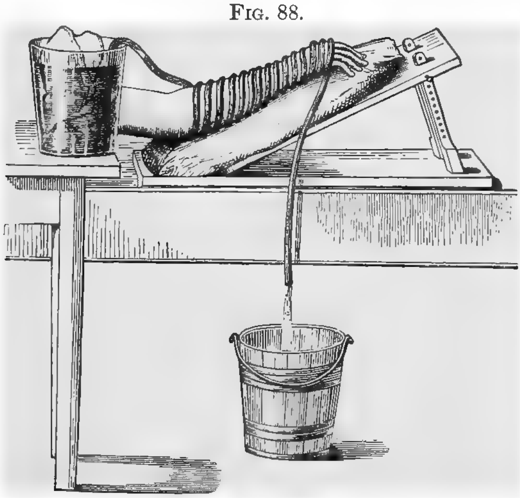
upon the part to be irrigated, which should be placed upon a piece of rubber sheeting so arranged as to allow the water to run off in a recep-

tacle, so as to prevent the wetting of the patient's bed. The water employed may be either cold or warm, and this is decided by the indications in special cases, and if it is desired to make use of antiseptic irrigation, the water is impregnated with carbolic acid or bichloride of mercury, a 1 : 5000 to 1 : 10,000 bichloride solution, or a 1 : 60 carbolic acid solution is frequently employed with good results.

Antiseptic irrigation employed in this manner will be found a most useful method in treating lacerated and contused wounds of the extremities in which the vitality of the tissues are impaired, and in such cases warm water should be preferred to cold water, the temperature being from 100° to 110° F. Under the use of warm irrigation it is surprising to see how tissues apparently devitalized regain their vitality. The absence of tension from the non-introduction of sutures or firm dressings, and the warmth and moisture kept constantly in contact with the wound by this method of treatment, are the important factors in the attainment of this favorable result.

Mediate Irrigation.—In applying mediate irrigation cold or warm water is passed through a rubber tube in contact with the part. A flexible tube of india-rubber half an inch in diameter, with thin walls, and sixteen or twenty feet in length, is applied to the limb like a spiral bandage or is applied in a coil to the head, breasts, or joints, and is held in place by a few turns of a bandage (Fig. 88). The end of the tube

Fig. 88.



Mediate irrigation (Esmarch).

is attached to a reservoir filled with cold or warm water above the level of the patient's body, and the water is allowed to flow constantly through the tube and escape into a receptacle arranged to receive it.

Cold-water Dressings.—These dressings are applied by bringing the cold water either directly in contact with the part or by applying it by means of a rubber bag or bladder. The temperature of the water may be varied from cool water to that of ice-water.

These dressings are employed in local inflammatory conditions: a

favorite method is by means of *cold compresses*, which are made of a few layers of surgical lint dipped in water of the desired temperature and applied to the part; they are renewed as soon as they become warm. When it is desired to have the compresses very cold, they may be laid upon a block of ice or in a basin of broken ice. To obtain the best results from their employment they should be renewed at very short intervals.

Ice-bag.—A very convenient method of applying cold without moisture is by the use of the ice-bag. This is either a rubber bag or a bladder which is filled with broken ice and applied to the part. In using the ice-bag it is better to cover the part first with a towel or a few layers of lint or muslin, which prevents the surface from becoming wet by absorbing the moisture which condenses upon the surface of the bag or bladder, and thus renders the dressing more comfortable to the patient. The ice-bag is often employed as an application to the head in inflammatory conditions of the brain or membranes, and is also used upon the surface of the body to control internal hemorrhage.

Counter-irritation.

Counter-irritants are substances employed to excite external irritation, and the extent of their action varies according to the materials used and duration of its application: superficial redness or complete destruction of the vitality of the parts to which they are applied may result. The use of counter-irritants under favorable circumstances is found to have a decided effect in modifying morbid processes, and they are widely employed as local revulsants in cases of congestion or inflammation, and in cases of collapse for their stimulating effect.

Rubefacients.—These agents, by reason of their irritating properties when applied to the skin, produce intense redness and congestion.

Hot Water.—When it is desired to make a quick impression on the skin, the application of muslin or flannel cloths wrung out in hot water and renewed as rapidly as they become cool will soon produce a superficial redness of the integuments.

Spirits of Turpentine.—This drug, applied to the skin, is a very active counter-irritant; it may be rubbed upon the surface of the skin until redness results. When used upon patients whose skin is very delicate, its action may be modified by mixing it with equal parts of olive oil before applying it; this will be found a useful precaution in applying it as a rubefacient to the tender skins of young children. When redness of the skin has resulted from the application, the skin should be wiped dry by means of a soft towel or absorbent cotton to remove from the surface any turpentine, which by its continued contact may cause vesication.

Turpentine Stupe.—Turpentine is often employed as a rubefacient by sprinkling spirits of turpentine over flannel which has been wrung out of boiling water or by dipping hot flannel in warm spirits of turpentine; prepared in either way, the stupe should be squeezed as dry as possible to remove the excess of turpentine before being applied to the surface of the body. A turpentine stupe may cause vesication if allowed to remain for too long a time in contact with the skin; its application for from five

to ten minutes will usually produce the desired effect; it should be removed after this time, and can be reapplied if desired. If the patient complains of severe burning of the skin after the use of turpentine, the painful surface should be freely smeared with vaseline, which will relieve this uncomfortable symptom.

Chloroform.—A few drops of chloroform applied to the surface of the body by means of a piece of lint, muslin, or flannel, and covered by oiled silk or rubber tissue, will excite a rapid rubefacient effect.

Mustard.—Ground mustard or mustard flour, prepared from either *Sinapis alba* or *Sinapis nigra*, is one of the most commonly-used substances to produce rubefacient action. It is generally employed in the form of the *mustard plaster* or *sinapism*, which is prepared by mixing equal parts of mustard flour with wheat flour or flaxseed meal, and adding enough warm water to make a thick paste. This is spread upon a piece of old muslin, and the surface of the paste should be covered with some thin material, such as gauze, to prevent the paste from adhering to the skin. In making a mustard plaster for application to the tender skin of a child one part of mustard flour should be mixed with three parts of wheat flour or flaxseed meal. A mustard plaster or sinapism may be allowed to remain in contact with the skin for a period varying from fifteen to twenty minutes, the time being governed by the sensations of the patient; if it is allowed to remain longer, it may cause vesication, which is to be avoided, as ulcers produced by mustard are very painful and extremely slow in healing. After removing a sinapism the irritated surface of the skin should be dressed with a piece of muslin or lint spread with vaseline, boric acid, or oxide-of-zinc ointment.

Mustard Foot-bath.—To excite a rapid rubefacient action a mustard foot-bath is often employed: it is prepared by adding four tablespoonfuls of mustard flour to a bucket or foot-tub of water at a temperature of 100° to 110° F.; in this the patient is allowed to soak his feet for a few minutes.

Mustard Papers.—*Charta Sinapis*, which can be obtained in the shops ready for use, are a convenient means of obtaining the rubefacient action of mustard. They are dipped in warm water, and, as they are generally very strong, it is well to place a piece of muslin between the plaster and the skin before applying it to the surface.

Capsicum or *Cayenne pepper* is also employed as a rubefacient, but it is generally used in conjunction with spices, forming the well-known *spice plaster*, which is prepared by taking equal parts of ground ginger, cloves, cinnamon, and allspice, and adding to them one-fourth part of Cayenne pepper; these are thoroughly mixed and enclosed in a flannel bag, and evenly distributed; a few stitches should be passed through the bag at different points to prevent the powder from shifting its position; before applying it one side of the bag should be wet with warm whiskey or alcohol. *Capsicine plasters* are also employed to obtain the rubefacient effect of Cayenne pepper.

Aqua ammoniæ may also be employed for its rubefacient action. A piece of lint saturated with the stronger water of ammonia, placed upon the skin and covered with waxed paper, and allowed to remain for one or two minutes, will produce a marked rubefacient effect.

Paquelin's Cautery.—By rapidly stroking the surface of the skin with

the point or button of Paquelin's cautery at a black heat a marked counter-irritant action may be produced.

Caution should be exercised in applying counter-irritation to patients who are comatose or under the influence of a narcotic, for here the sensations of the patient cannot be used as a guide to their removal, and the too long-continued application when the vitality of the patient is impaired may result in serious consequences.

Vesicants.—When it is desirable to make a more permanent counter-irritant effect than that produced by rubefacients, substances are employed which by their action on the skin cause an effusion of serum, or of serum and lymph, beneath the cuticle, thus giving rise to vesicles or blisters; they are known as vesicants.

The substance most commonly employed to produce vesication is *cantharis*, or *Spanish fly*, and the preparation commonly used is *Ceratum Cantharidis*, which is used in the form of the fly blister. This is prepared by spreading the cerate upon adhesive plaster, leaving a margin half an inch in width, which adheres to the skin and holds the plaster in position. The time usually required for a fly blister to produce vesication is from four to six hours; it should then be removed and the surface should be covered with a flaxseed-meal poultice or with a warm-water dressing. When the blister or vesicle is well developed, it may be punctured at its most dependent part to allow the serum to escape, and it should be dressed with vaseline or boric ointment. If for any reason it is desired to keep up continued irritation after allowing the serum to escape, the cuticle should be cut away and the raw surface should be dressed with some stimulating material, such as the compound resin cerate.

Cantharidal collodion may also be employed to produce vesication; it is applied by painting several layers upon the skin with a brush over the part upon which the blister is to be produced. It is a convenient preparation to use when the patient would disturb the ordinary blister, as in the case of a child or an insane patient, or where the surface is so irregular that the ordinary blister cannot be well applied. The after-treatment of blisters produced by the use of the collodion is similar to that previously described.

In the treatment of chronic inflammation it is often better to employ a number of small blisters at intervals than one large blister producing an extensive vesication of the surface. Care should be observed in using blisters upon the tender skins of children; if employed, they should be allowed to remain in contact with the skin for a short time only. They are contraindicated in patients whose vitality is depressed by adynamic diseases and in aged persons.

A complication which sometimes arises from the use of cantharidal preparations is *strangury*, which is shown by frequent and painful micturition, the urine often containing blood. This accident should be treated by the use of opium and belladonna by suppository, demulcent drinks, and warm sitz-baths, and by leeches to the perineum if the symptoms are very severe.

To avoid the development of strangury small blisters should be employed, they should not be allowed to remain too long in contact with the surface, and cantharidal preparations should not be employed

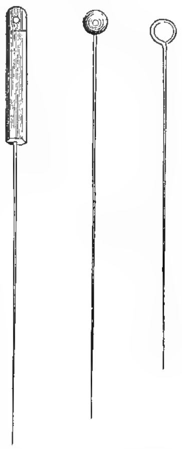
in cases where renal or vesical irritation has existed or is present. Strangury may be also avoided by incorporating opium and camphor with the cantharidal cerate.

Aqua ammoniæ fortior and *chloroform* may be employed to produce rapid vesication, a few drops being placed upon the surface of the body and covered by an inverted watch-glass for a few minutes, or lint saturated with aqua ammonia or chloroform may be placed upon the skin and covered with waxed paper or oiled silk. Either of these agents applied in this manner and allowed to remain in contact with the skin for fifteen minutes will produce marked vesication. The blisters resulting from these agents are painful, and they are only to be used where rapid result is desired.

Nitrate of silver, in a strong solution or in the form of the solid stick, may be applied to the surface of the skin to produce a counter-irritant effect. Nitrate of silver, applied by drawing the moist stick across the skin of the scrotum at a number of points, was formerly a popular treatment for acute epididymitis.

Acupuncture.—In this method of counter-irritation needles are thrust deeply into the subcutaneous tissues. The needles employed for this purpose should be of steel, from two to four inches in length, strong, highly polished, and sharp-pointed, and should have round metallic heads or be fixed in handles (Fig. 89). They should be rendered perfectly aseptic by being allowed to remain for a few minutes in boiling water or in a carbolized solution. In performing the operation of acupuncture localities containing important organs, large blood-vessels, nerves, the joints, and viscera should be avoided. When introduced, the needles should be passed through the skin with a rotary motion, the skin being rendered tense between the thumb and fingers, and thrust into the deep-seated structures. They are allowed to remain in position for a few minutes, and are then withdrawn, the skin being supported by the thumb and fingers. Acupuncture has been found of service in deep-seated neuralgias, obstinate rheumatic affections, and sciatica.

FIG. 89.



Acupuncture needles.

Issues.—Issues are ulcers made intentionally by the application of caustics, the moxa, or the knife. They are not much employed at the present time, but were formerly a popular means of causing long-continued counter-irritation. In making an issue a region was selected where the subcutaneous cellular tissue was abundant and which was free from large blood-vessels and nerves, and not near the joints. The plan usually adopted was to apply over the surface of the skin a piece of adhesive plaster perforated in the centre. A small piece of caustic potash or Vienna caustic, mixed with water to make it a paste, was placed in the hole in the adhesive plaster and held in position by a strip of adhesive plaster. In one or two hours the plaster should be removed, and the parts should be washed with dilute acid to prevent further action of the caustic; a poultice of flaxseed should next be applied to hasten the separation of the slough. The ulcer remaining after the removal of the slough was kept from healing

by introducing into it a small wooden ball known as an *issue pea*, or a glass bead or pebble, held in place by a compress and adhesive strip.

FIG. 90.

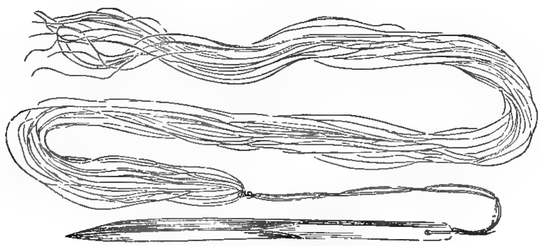
Porte-moxa.

The knife was also employed to establish an issue, a crucial incision being made between the skin and cellular tissues into the deep tissues; the objection to the use of the knife in forming an issue was the difficulty in preventing the wound from healing.

The moxa was formerly used to make an issue: it consisted of a small mass of some combustible material, such as punk, cotton, or lint, rolled into pyramidal shape, which was placed upon the surface of the body and ignited so as to produce an eschar upon the skin. To facilitate the application of the moxa an instrument called the porte-moxa was employed (Fig. 90). The treatment of the eschar resulting from the moxa is the same as that resulting from the use of caustic potash.

The Seton.—A seton is a subcutaneous sinus or an issue with two openings upon the surface, which is prevented from healing by the

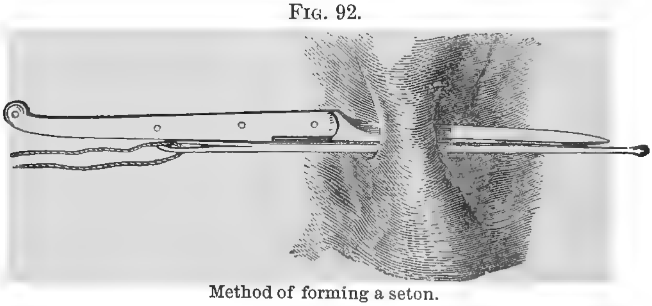
FIG. 91.



Seton needle.

introduction of a foreign body. It is established by introducing a few strands of silk, a narrow strip of linen, or a rubber ligature by means of a seton needle (Fig. 91). The seton needle should be passed deeply

FIG. 92.



Method of forming a seton.

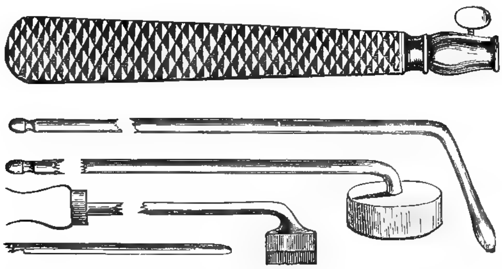
into the superficial fascia, care being taken to avoid important veins and nerves.

A seton may also be established by pinching up a fold of skin and transfixing its base with a narrow, sharp-pointed bistoury (Fig. 92), and passing through the wound thus made an eyed probe armed with a

few strands of silk, a strip of muslin, or an elastic ligature; the probe is then removed and the ends are loosely tied together. At each change of the dressing the strip or seton should be made to change its position by drawing it forward or backward, and it may be smeared with some stimulating ointment, which can thus be brought in contact with the granulating surface of the sinus.

Actual Cautery.—This method of counter-irritation is accomplished by bringing in contact with the skin some metallic substance brought to a red heat. This constitutes one of the most powerful means of counter-irritation and revulsion; it is rapid in its action, and is not more painful than some of the slower methods. The cauteries generally employed are made of iron, fixed in handles of wood or other non-conducting material, and have their extremities fashioned in a variety of shapes (Fig. 93). The cautery-irons are heated by placing their extremities

FIG. 93.



Cautery-irons.

in an ordinary fire or by holding them in the flame of a spirit-lamp until they are heated to the desired point, either to a bright or dull-red heat. They are then applied to the surface of the skin at one point, or drawn over the skin in lines either parallel to or crossing one another. The intense burning which follows the use of the cautery may be allayed by placing upon the cautery-marks compresses wrung out in ice-water or saturated with equal parts of lime-water and sweet oil.

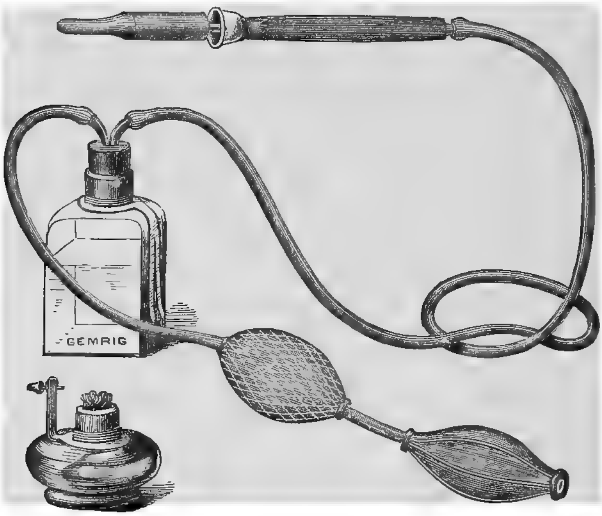
When the ordinary cautery-irons are not at hand, a steel knitting-needle or iron poker heated in the flame of a spirit-lamp or in a fire may be employed with equally satisfactory results. Where the cautery-iron is held in contact with the surface for some time to make a deep burn, the pain of its application may be allayed by placing a mixture of salt and cracked ice upon the spot to be cauterized for a few minutes immediately before its application. The cautery-iron should not be placed over the skin covering salient parts of the skeleton or over important organs.

Actual cautery, in addition to its use in producing counter-irritation and revulsion, is often employed to control hemorrhage and to destroy morbid growths.

Paquelin's Thermo-cautery.—The apparatus of Paquelin constitutes a very convenient and efficient means of using a thermo-cautery: it utilizes the property of heated platinum-sponge to become incandescent when exposed to the action of the vapor of benzole or rhigolene (Fig. 94). The cautery is prepared for use by attaching the gum tube to the receiver containing benzole, and heating the platinum knife or

button, which is attached to the benzole receiver by a rubber tube, in the flame of an alcohol lamp for a few minutes, and then passing the vapor of benzole through the platinum-sponge, which is enclosed in

Fig. 94.



Paquelin's cautery.

the knife or button, by compressing the rubber bulb. The cautery points may be brought either to a high degree of heat, or only to a dull-red heat. This form of cautery may be employed for the same purposes as that previously mentioned; its great advantage consists in the ease with which it can be prepared for use. In this form of cautery the knife, heated to a dull-red heat, will be found of great service in operating upon vascular tumors, where the use of an ordinary knife would be accompanied by profuse or even dangerous hemorrhage. Wounds made by the actual cautery are aseptic wounds, and when dusted with iodoform will usually heal promptly under the scab without suppuration.

Bloodletting.

Bloodletting is resorted to to obtain both the local and general effects following the withdrawal of blood from the circulation. Local depletion is accomplished by means of some one of the following procedures: scarification, puncturation, cupping, and leeching, and general depletion is effected by means of venesection or arteriotomy.

Scarification.—Scarification is accomplished by making small and not too deep incisions into an inflamed or congested part with a sharp-pointed bistoury; the incisions should be in parallel lines and should be made to correspond to the long axis of the part, and care should be taken in making them to avoid wounding superficial nerves and veins. Incisions thus made relieve tension by allowing blood and serum to escape from the engorged capillaries of the infiltrated tissue of the part. Warm fomentations applied over the incisions will increase and keep up the flow of blood and serum. Scarification is employed with advantage in

inflammatory conditions of the skin and subcutaneous cellular tissue, and in acute inflammatory swelling or œdema of the mucous membrane—for instance, of the conjunctiva; and in acute inflammation of the tonsils, tongue, and epiglottis it is an especially valuable procedure.

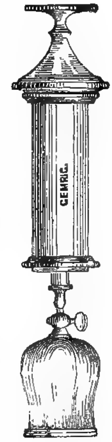
Deep Incisions.—A modification of scarification known as *deep incisions* is practised by making deep incisions into the inflamed or infiltrated tissues, care being taken to avoid the wounding of important vessels and nerves. This procedure is practised in urinary infiltration to establish drainage and relieve the tissues of the contained urine and to prevent sloughing; in threatened gangrene and phlegmonous erysipelas the same procedure is adopted to relieve tension by permitting the escape of blood and serum, and its employment is often followed by most satisfactory results.

Puncturation.—Puncturation consists in making punctures, which should not extend deeper than the subcutaneous tissue, into inflamed tissues with the point of a sharp-pointed bistoury: it is an operation similar in character to that just described, its object being to relieve tension and bring about depletion. It is employed in cases similar to those in which scarification is indicated, and is resorted to in cases of diffuse areolar inflammation or erysipelas.

Cupping.—Cupping is a convenient method of accomplishing local depletion by inviting the blood from the deeper parts to the surface of the skin. Cupping is accomplished by the use of *wet* or *dry* cups. When dry cups are used, no blood is abstracted and the derivative action only is obtained; when wet cups are employed, there is an actual abstraction of blood or local depletion, as well as the derivative action.

Dry Cupping.—Dry cupping as ordinarily applied consists in the use of small cup-shaped glasses which have a valve and stopcock at their summit: these are placed upon the skin and an air-pump is attached, and as the air is exhausted in the cup the congested integument is seen to bulge into the cavity of the cup (Fig. 95). When the exhaustion is complete the stopcock is turned and the air-pump is removed, the cup being allowed to remain in position for a few minutes, and it is then removed by turning the stopcock and allowing the air again to enter the cup. This procedure is repeated until a sufficient number of cups have been applied.

Fig. 95.



Cupping-glass and air-pump.

In cases of emergency, when the ordinary cupping-glasses and air-pump cannot be obtained, a very satisfactory substitute may be obtained by taking an ordinary glass and burning in it a little roll of paper or a small piece of lint or paper wet with alcohol, and before the flame is extinguished rapidly inverting it upon the skin, or the air may be exhausted by the introduction into the cup, for a moment or two, of the flame of a spirit-lamp. Applied in this manner, cups will draw as well as when the more complicated apparatus is used, and when they are removed it is only necessary to press the finger on the skin close to the edge of the cup until air enters, when it will fall off.

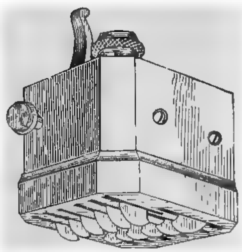
Although dry cups do not remove blood, there is often an escape of blood from the capillaries into the skin and cellular tissue,

as is evidenced by the ecchymosis which frequently remains at the seat of the cup-marks for some days. Dry cups, as previously stated, are employed for their derivative action in cases in which depletion is not indicated.

Wet Cupping.—Wet cups are resorted to when the abstraction of the blood as well as the derivative action is desired, and here it is necessary to have a scarificator as well as the cups and air-pump.

Before applying wet cups the skin should be carefully washed with a carbolic solution, and the scarificator (Fig. 96) should also be dipped in the same solution. A cup is first applied to produce superficial congestion of the skin; this is removed and the scarificator is applied, and the skin is cut by springing the blades, and the cups are immediately applied and exhausted; and they are kept in place as long as blood continues to flow. When the vacuum is exhausted and blood ceases to flow, they should be removed and emptied, and can be reapplied if it is desirable to remove more blood. A sharp-pointed bistoury which has been sterilized may be employed to make a few incisions into the skin instead of the scarificator, and the improvised cups may be employed if the ordinary cupping apparatus cannot be obtained. After the removal of wet cups the skin should be washed carefully with bichloride or carbolic solution, and an antiseptic dressing should be applied and held in place by a roller bandage.

Fig. 96.



Scarificator.

Leeching.—Two varieties of leeches are used in the abstraction of blood by leeching—the *American* leech, which draws about a teaspoonful of blood, and the *Swedish* leech, which draws three or four teaspoonfuls.

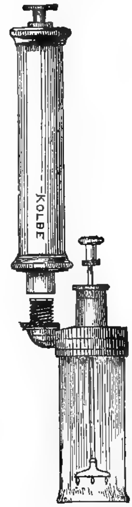
Before applying leeches the skin should be carefully washed, and the leech should be placed upon the part from which the blood is to be drawn, and confined to this place by inverting a tumbler or glass jar over him; if he does not bite or take hold, a little milk or blood should be smeared upon the surface, which will generally secure the desired result. As soon as the leech has ceased to draw blood he is apt to let go his hold and fall off; if, however, it is desired to remove leeches, they may be made to let go their hold by sprinkling them with a little salt. After the removal of leeches, bleeding from the bites may be encouraged by the application of warm fomentations. Leech-bites should be washed with a bichloride or carbolic solution, and a compress of bichloride or iodoform gauze should be placed over them and secured by a bandage. It occasionally happens that free bleeding continues from the leech-bite after the removal of the leech; in this event, if a compress does not control the hemorrhage, the bleeding points should be touched with a stick of nitrate of silver or with the point of a steel knitting-needle heated to a dull-red heat; and if this fails to control the bleeding a delicate hare-lip pin should be passed through the skin under the bite, and a twisted suture should be thrown around this; the wound should then be washed and dressed as previously described.

In applying leeches in or near mucous cavities care should be taken to see that they do not escape into the cavities and pass out of reach.

Leeches should not be employed directly over inflamed tissues, but should be applied to the parts surrounding them; they should not be allowed to take hold directly over a superficial artery, vein, or nerve; and should never be applied to a part where there is delicate skin and a large amount of loose cellular tissue, as in the eyelid or scrotum, as unsightly ecchymoses will result which will persist for some time. Leeches should not be used a second time.

Mechanical Leech.—A mechanical leech consists of a scarificator, cup, and exhausting syringe or air-pump (Fig. 97). In using this apparatus, after the scarificator has been used the piston of the exhausting instrument should be drawn out slowly, which secures a better flow of blood than if a sudden vacuum is made.

FIG. 97.

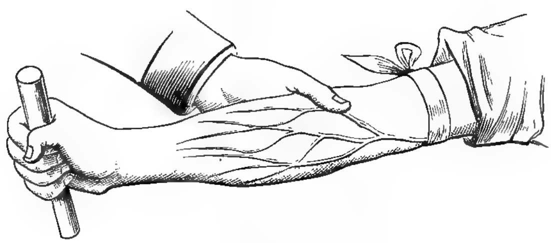


Mechanical leech.

The mechanical leech may be employed when the natural leech cannot be obtained, but possesses no advantage over the latter, and is apt to get out of order if not in constant use.

Venesection.—Venesection consists in the division or opening of a vein, and is the ordinary operation by which general depletion or bleeding is accomplished. Venesection at the bend of the elbow is the operation which is now usually resorted to for general bloodletting; the vein selected is the *median cephalic*, which is farther from the line of the brachial artery than the median basilic vein (Fig. 98).

FIG. 98.



Venesection (Heath).

To perform venesection the surgeon requires a bistoury or lancet—the spring lancet was formerly much used, but it is not employed at the present time—several bandages, a small antiseptic dressing, and a basin to receive the blood. The patient's arm should be carefully cleansed, washed with a bichloride solution, and a few turns of a roller bandage should be placed around the middle of the arm, being applied tightly enough to obstruct the venous circulation and make the veins below become prominent, but not to obstruct the arterial circulation. The patient at the same time should be instructed to grasp a stick or a roller bandage and work his finger upon it. The surgeon should next assure himself that there is no abnormal artery beneath the skin, and having selected the vein, the median cephalic by preference, he steadies the vein with his thumb and passes the point of the bistoury or lancet beneath and cuts quickly outward, making a free skin opening. The blood usually

escapes freely, and the amount withdrawn is regulated by the condition of the pulse and appearance of the patient. For this reason it is better to have the patient sitting up or semi-reclining when venesection is performed, as the surgeon can judge better as to the constitutional effects of the loss of blood while the patient is in this position. When a sufficient quantity of blood has been removed, the thumb is placed over the wounded vein and the bandage is removed from the arm above. The wound is next washed with a bichloride solution, and a compress of antiseptic gauze is applied over it and held in position by a bandage, which should be so applied as to envelop the arm from the fingers to the axilla. The dressing need not be disturbed for five or six days, at which time the wound is usually found to be healed.

The brachial artery has been wounded in performing venesection at the bend of the elbow, but if care is taken this accident should not occur.

Venesection has been practised on the *external jugular vein* when, from the excess of fat or in the case of children, the veins at the bend of the elbow cannot be easily found. The vein is rendered prominent by placing the thumb or a pad over the vein at the outer edge of the sterno-cleido-mastoid muscle just above the clavicle. The vein is next opened over this muscle by an incision parallel to its fibres. After a sufficient quantity of blood has escaped the wound is washed with an antiseptic solution, and closed by a compress of antiseptic gauze held in position by a bandage carried around the neck.

The *internal saphena vein* has also been selected for venesection, and here care should be taken not to wound the accompanying nerve, which lies directly behind the vein.

Arteriotomy.—This operation is now scarcely ever performed, but if done the vessel generally selected is the anterior branch of the temporal artery, which is opened by a transverse incision with a bistoury. After a sufficient quantity of blood has escaped the wound is inspected, and if the vessel is not completely divided its division is completed, and the ends of the vessel secured with catgut ligatures and the wound douched with an antiseptic solution. A gauze compress should be applied and held in position by a firmly-applied bandage.

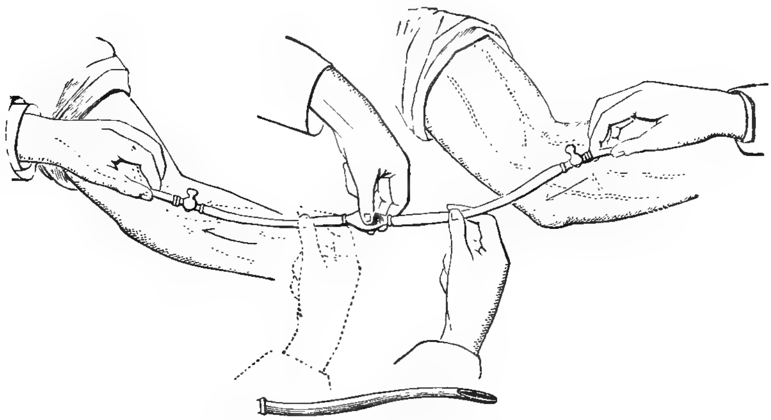
Transfusion of Blood.

Transfusion of blood may be employed to introduce a certain quantity of blood into the circulation of a patient who has suffered from profuse hemorrhage. There are two methods by which transfusion may be effected: the direct, by which the blood is conveyed directly and without exposure to the air from the blood-vessel of one person to that of another, and the indirect, in which the blood is drawn from the vein of one person and is then injected into the vein of another, being first deprived of its fibrin before being injected.

Direct Transfusion of Blood.—This is best accomplished by using Aveling's apparatus, which consists of a rubber tube about eighteen inches in length, with a small rubber bulb in the centre, having metallic extremities provided with stopcocks, and two bevel-pointed metallic canulæ, to be used to connect the tube with the blood-vessels. In per-

forming the operation of direct transfusion the bulb and tube are first placed in a shallow basin containing warm normal saline solution (0.7 per cent.), and the bulb and tube are filled with this solution to displace any air which they contain. The person supplying the blood places his arm near the arm of the patient, and the operator exposes a prominent vein of the patient's arm at the bend of the elbow and opens it, and inserts into it one of the canulæ filled with saline solution, with the point directed toward the body, and at the same time an assistant should introduce the other canula into a vein at the bend of the elbow of the person who supplies the blood. The canulæ are held in position by assistants, and the tube is quickly connected with them, the stopcock being closed before it is taken out of the saline solution, to prevent the entrance of air; then upon opening the stopcocks a direct connection is established between the circulation of the patient and that of the person who supplies the blood (Fig. 99).

FIG. 99.



Apparatus for the direct transfusion of blood.

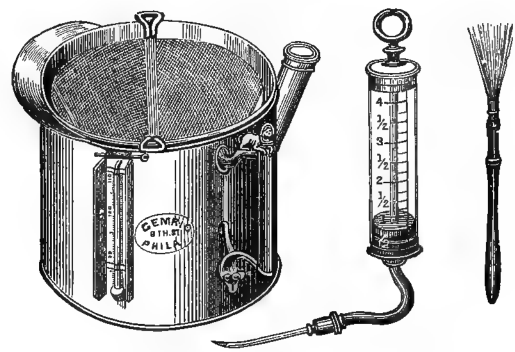
The introduction of the contents of the bulb into the vein of the patient is effected by the operator slowly compressing the bulb with one hand, while he keeps the tube closed on the side of the donor with the finger and thumb of the other hand. By relaxing the pressure on the donor's side of the bulb, and closing it on the patient's side, blood will flow from the donor into the bulb as it slowly expands, and when filled the communication with the patient's circulation is again made, and the manipulation is repeated until a sufficient quantity of blood has been introduced, as indicated by the condition of the patient's pulse. The quantity of blood or saline solution introduced can be calculated by remembering that at each emptying of the bulb two drachms of fluid are introduced into the circulation. When a sufficient quantity has been introduced the canulæ are removed and the wounds are dressed as ordinary venesection-wounds.

Indirect Transfusion of Blood.—Indirect transfusion of blood is accomplished by withdrawing from the vein of the donor by venesection about ten ounces of blood, which is received into a clean glass or porce-

lain vessel which is placed in water at a temperature of 110° F. The blood thus kept warm is next defibrinated by whipping it with a bundle of broom straws or a wire brush, and after being filtered through a fine linen cloth or wire strainer it is injected by means of an ordinary syringe attached to a canula which has been previously inserted into the vein of the patient, care being taken that no air is introduced with the blood. When a sufficient quantity of blood has been introduced the canula is removed and the wound is dressed in the usual manner. The success of this operation depends largely upon the expedition with which it is performed; to prevent coagulation of the blood, not more than two minutes should be allowed to intervene between the reception of the blood in the syringe and its introduction into the patient's vein.

The best form of apparatus for indirect transfusion of blood is that devised by Dr. J. G. Allen and modified by the late Dr. C. T. Hunter (Fig. 100).

FIG. 100.



Apparatus for indirect transfusion of blood.

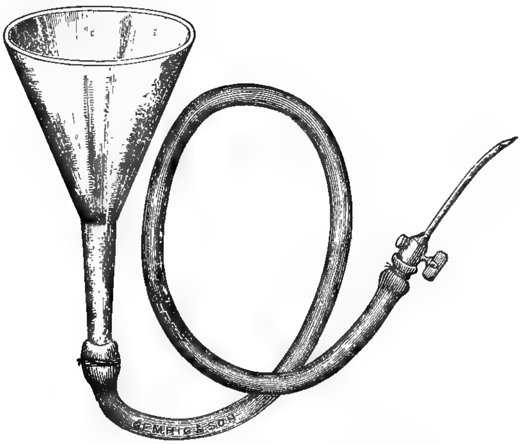
Arterial Transfusion.—This procedure, which consists in injecting defibrinated venous blood into an artery, is occasionally practised. An artery, usually the radial at the wrist or the posterior tibial behind the inner malleolus, is exposed and secured by a ligature; it is then opened on the distal side of the ligature, and the point of a canula or the nozzle of a syringe is introduced directed toward the distal extremity of the limb, and blood which has been previously defibrinated is slowly injected. When a sufficient quantity has been introduced the canula is removed, the division of the artery is completed, its extremities are secured by ligatures, and the wound is closed and dressed.

Auto-transfusion.—Auto-transfusion is a procedure which is recommended in cases of excessive hemorrhage to support a moribund patient until other means of resuscitation can be adopted. It consists in the application of rubber bandages or of muslin bandages to the extremities for the purpose of forcing the blood toward the vascular and nervous centres.

Intra-venous Injection of Saline Solution.—The injection into the veins of normal salt solution has been proved by experiment and by clinical experience to be more efficacious in supplying volume to and restoring a rapidly-failing circulation than human blood, and, as the

former can be obtained with much more ease than blood, its use has largely superseded the latter. The saline solution which is found most satisfactory to employ for this purpose is known as normal saline solution (0.7 per cent.), prepared by adding a drachm of salt to one pint of boiled water. The solution should be prepared with water which has been sterilized by boiling, and should be at a temperature of 100° F. when used. A vein of the patient, at the elbow, should be exposed, and should have placed under it, about half an inch apart, two catgut ligatures; the distal ligature is then tied and an opening is made into the vein between the ligatures. A canula is next inserted into the opening in the vein, and is secured in position by tying the proximal ligature. The canula is first filled with the saline solution, and is then connected with a funnel by means of a rubber tube (Fig. 101), which is filled with

FIG. 101.



Funnel and tube for intra-venous injection.

saline solution to displace the air, and upon raising the funnel above the part the solution enters the vein; care should be taken to see that the funnel is kept well filled with solution until a sufficient quantity has been introduced. The quantity introduced is regulated by the condition of the patient's pulse.

Saline solution may also be introduced by means of a syringe when the apparatus described cannot be obtained. Large injections of normal salt solution may be introduced into the cellular tissue by means of hypodermic injections, or the needle may be introduced into the cellular tissue and connected by a piece of rubber tubing, with an irrigator containing normal salt solution held above the part, and the solution gradually finds its way into the subcutaneous cellular tissue. A large quantity of fluid may be introduced in this way.

Intra-venous Injection of Milk.—The intra-venous injection of cow's or goat's milk has also been employed as a substitute for transfusion of blood in patients who have suffered from excessive hemorrhage or from diseases which greatly deteriorate the quality of the blood. In making one of these injections the same apparatus is employed and the

steps of procedure are similar to those used in making intra-venous injection of saline solution. The milk to be injected should be fresh, and should be warmed and strained through a fine wire or linen strainer. This injection has been employed in cases of pernicious anæmia, typhoid fever, and carbolic-acid poisoning with apparently beneficial results.

Artificial Respiration.

Artificial respiration is resorted to in cases of threatened death from apnœa consequent upon drowning, profound anæsthetization, or the inhalation of irrespirable gases, or where from any cause there is interference with the function of breathing. Before resorting to artificial respiration care should be taken that the mouth and air-passages are free from any substance which would obstruct the entrance of air into the lungs, such as mucus, foreign bodies, or liquids, and also that all tight clothing interfering with the free expansion of the chest-walls is removed from the chest. Where apnœa is due to a foreign body in the larynx or trachea tracheotomy should be performed before artificial respiration is attempted.

When artificial respiration is resorted to, it should be persevered with for some time, even when no apparent spontaneous respiratory movements are excited; for resuscitation has been accomplished in seemingly hopeless cases by patient perseverance with the manipulations. When the first natural respiratory movement is detected the operator should not cease making artificial respiration, but should continue these movements in such a way as to coincide with the spontaneous inspiratory and expiratory movements until the breathing has assumed its regular character.

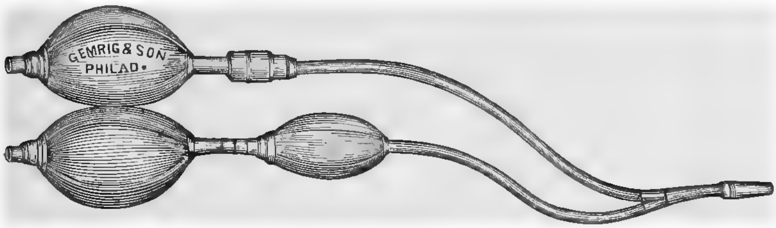
The temperature of the body should also be restored by frictions to the surface of the body by the hands or by rough towels, and hot-water bottles and warm coverings should be applied with the same object.

Mouth-to-mouth Inflation.—This method of artificial respiration has been resorted to in cases of great emergency, especially in very young children. The operator draws the tongue forward, closes the nostrils, applies his mouth directly to the mouth of the patient, and by a deep expiratory effort endeavors to force air into the chest; when this is accomplished the air can be expelled from the lungs by pressure upon the walls of the chest, and the procedure should be repeated about twelve or sixteen times in a minute. The same object may be accomplished by passing a flexible catheter into the trachea through the mouth, or by passing an intubation-tube, to the upper part of which a rubber tube is attached, into the larynx; this can be passed with the fingers without difficulty, and the lungs can then be inflated by the operator blowing into the mouth or tube or by attaching to it a pair of bellows.

Dr. Richardson of London has devised a pocket-bellows for inflation of the lungs through the nostrils (Fig. 102). The apparatus consists of two elastic bulbs to which two rubber tubes are attached, which terminate in a single tube. In using this bellows the terminal tube is introduced into one nostril, the other nostril and mouth being closed; air is

forced into the lungs by compressing one bulb, and withdrawn by compressing the other.

Fig. 102.



Richardson's bellows for artificial respiration.

Howard's Direct Method of Artificial Respiration.—This method of artificial respiration is the one adopted by the United States Life-saving Service, and is considered the most efficacious, and, although the rules given are for the resuscitation of cases of apparent drowning, the same procedure may be adopted in cases of apnœa arising from other causes.

The rules of Howard's method of artificial respiration are as follows:

Rule I.—"To expel air from the stomach and lungs, strip the patient to the waist, and if the jaws are clenched separate them and keep them apart by placing between them a piece of cork or a small piece of wood. Place the patient's face downward, the pit of the stomach being raised above the level of the mouth by a large roll of clothing placed beneath it (Fig. 103). Throw your weight forcibly two or three times upon the patient's back over the roll of clothing, so as to press all fluids in the stomach out of the mouth."

Fig. 103.

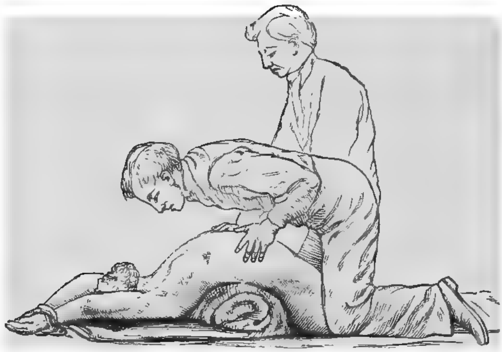
First manipulation in Howard's method.

The first rule applies only to cases of drowning, and in using Howard's method in apnœa from other causes it is to be omitted.

Rule II.—"To perform artificial respiration, quickly turn the patient upon his back, placing the roll of clothing beneath it, so as to make the breast-bone the highest point of the body. Kneel beside or astride of the patient's hips. Grasp the front part of the chest on either side of

the pit of the stomach, resting the fingers along the spaces between the short ribs. Brace your elbows against your sides, and, steadily grasping and pressing forward and upward, throw your whole weight upon the chest, gradually increasing the pressure while you count one, two, three (Fig. 104). Then suddenly let go with a final push, which brings you back to your first position. Rest erect upon your knees while you count

Fig. 104.



Direct method of artificial respiration.

one, two; then make pressure again as before, repeating the entire motions at first about four or five times a minute, gradually increasing them to about ten or twelve times. Use the same regularity as in blowing bellows and as seen in the natural breathing, which you are imitating. If another person is present, let him with one hand, by means of a dry piece of linen, hold the tip of the tongue out of one corner of the mouth, and with the other hand grasp both wrists and pin them to the ground above the patient's head."

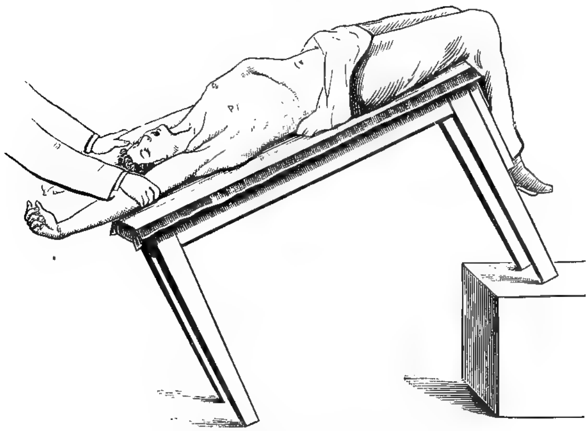
This method may be employed in cases of stillbirth or in young children, the operator holding the chest of the child in his left hand and compressing it with the right hand.

Sylvester's Method of Artificial Respiration.—In employing this method of artificial respiration the patient should be placed upon his back on a firm, flat surface; a cushion of clothing is placed under the shoulders, and the head should be dropped lower than the body by tilting the surface upon which he is laid. The mouth being cleared of mucus or foreign substances, the tongue is drawn forward and secured to the chin by a piece of tape tied around it and the lower jaw, or may be pulled out of the mouth and held by an assistant. The operator, standing at the patient's head, grasps the arms at the elbows and carries them first outward and then upward until the hands are brought above the head; this manipulation represents inspiration (Fig. 105): they should be kept in this position for two seconds, after which they are brought slowly back to the sides of the thorax and pressed against it for two seconds; this manipulation represents expiration (Fig. 106). These movements are repeated fifteen times in a minute until the breathing is restored or until it is evident that the case is a hopeless one.

Marshall Hall's Ready Method of Artificial Respiration.—In

practising this method of artificial respiration the mouth should first be freed from mucus or foreign bodies, and the patient is turned upon his face with one wrist under his forehead, and a roll of clothing is placed

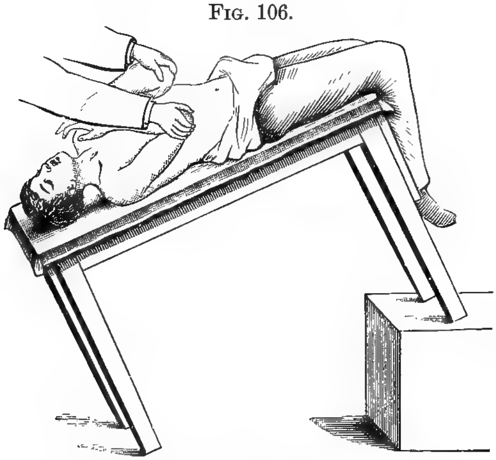
Fig. 105.



Sylvester's method: inspiration (Esmarch).

beneath his chest. By turning the body briskly on the side and a little beyond, and then on the face, alternately, respiration is imitated. As the body is brought into the prone position, compression is made upon

Fig. 106.



Sylvester's method: expiration (Esmarch).

the posterior aspect of the chest. These manipulations should be made fifteen times in a minute.

Laborde's Method of Artificial Respiration by Rhythmical Traction upon the Tongue.—Laborde states that systematic and rhythmic traction of the tongue is a powerful means of restoring the respiratory reflex, and consequently the function of respiration. The procedure is accomplished as follows: The body of the tongue is seized between the

thumb and finger, and traction is made upon it, with alternate relaxation, fifteen or twenty times a minute, imitating the function of respiration, taking care to draw well on the tongue. When a certain amount of resistance is felt, it is a sign that the respiratory function is being restored; noisy respiration first occurs, termed by Laborde "hoquet inspirateur" (inspiratory hiccough). Tongue forceps or dressing or hæmostatic forceps may be used in the place of the fingers to grasp the tongue. It is important to continue the traction with persistence for half an hour to an hour and a half.

The procedure is said to have been employed with success in cases of drowning, toxic asphyxia, chloroform asphyxia, tetanus, and asphyxia after electric shock.

In using any of these methods of artificial respiration the operator should persevere with them for from thirty minutes to an hour before abandoning the case as a hopeless one.

Forced Respiration.—This is a method of artificial respiration in which air is forcibly passed into the lungs through the mouth and larynx. This procedure has been strongly advocated by Dr. George E. Fell, who has devised an apparatus by which it can be satisfactorily accomplished. The apparatus of Fell, which has been used in a number of cases with good results, consists of a tracheotomy-tube, a tube connected with the air-control valve which is attached to an air-warming apparatus, which in turn is connected with a bellows by another tube. By means of this apparatus air is forced into the lungs, and allowed to escape when the lungs have been expanded by the elasticity of the lung-tissue and the chest-walls.

Prof. H. C. Wood has also employed forced respiration in the resuscitation of animals with an apparatus somewhat similar to that devised by Dr. Fell, with good results. Wood's apparatus consists of a pair of bellows, a few feet of rubber tubing, which are attached either to a face-mask of rubber or to an intubation-tube; the mask or intubation-tube is attached to one end of the rubber tube and the bellows to the other end of the tube. The mask is applied over the mouth, or, if this is not used, the intubation-tube is introduced into the larynx, and air is forced into the lungs by working the bellows. He also advises that in the tubing a double metal tube be introduced, with openings placed so that their size can be so regulated by turning the outer tube that the operator can allow any excess of air thrown by the bellows to escape. Forced respiration will prove of value in cases of narcotic poisoning and other accidents in which death is produced by paralysis of the respiratory centres. Dr. Fell has reported a number of cases of narcotic poisoning in which he has used his apparatus with the most satisfactory results.

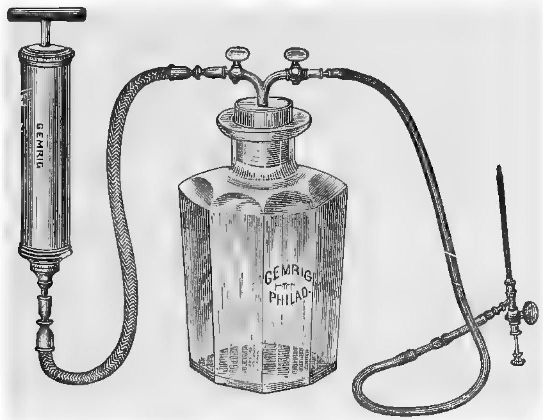
Aspiration.

This procedure is adopted to remove fluid from a closed cavity without the admission of air, and the instrument which is employed to accomplish this object is known as an "aspirator." Fluids may be removed simply by having an empty soft rubber bag or bladder attached to a sharp-pointed canula, which is introduced into a closed cavity, and the fluid by atmospheric pressure escapes and distends the bag.

The two forms of aspirator most commonly employed are those of Dieulafoy and Potain.

Potain's aspirator consists of a glass bottle, into the stopper of which is introduced a metallic tube, which is connected with two rubber tubes, one of which is connected with an exhausting-pump, and the other with a delicate canula carrying a fine trocar; the apparatus is provided with stopcocks to prevent the admission of air (Fig. 107). In using this

FIG. 107.



Potain's aspirator.

aspirator the bottle is exhausted of air by using the air-pump; the canula enclosing the trocar is next pushed through the tissues into the cavity containing the fluid to be removed; the trocar is next removed, and upon opening the stopcock the fluid is forced out of the cavity by atmospheric pressure and passes into the bottle or receiver. If the fluid contains masses of lymph or clots which block the canula, interrupting the flow of fluid, a stylet should be passed through the canula to free it of the obstruction.

To diminish the pain produced in introducing the trocar and canula the skin at the point to be punctured may be rendered less sensitive by holding in contact with it for a few minutes a piece of ice wrapped in a towel or a towel containing broken ice and salt. Care should be taken to see that the trocar and canula are perfectly clean: to accomplish this they should be carefully washed and placed in boiling water or a 5 per cent. carbolic solution before being used. After removing the trocar and canula the small puncture should be dressed with a compress of bichloride or iodoform gauze held in place by a bandage or adhesive straps.

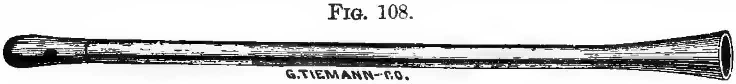
The aspirator is frequently employed in cases of hydrothorax, empyema, and ascites, to evacuate the contents of cold abscesses in diseases of the hip and spine, and to remove the contents of a distended bladder until a more radical operation can be performed. It is also a valuable instrument for diagnostic purposes, being frequently used to ascertain the character of the contents of deep-seated collections of fluid.

The Stomach-tube.

This consists of a flexible tube about twenty-eight inches in length and three-eighths of an inch in diameter, which is introduced while the patient is in the sitting posture, the head being thrown backward so as to bring the mouth and gullet as nearly as possible in the same line. The tube being warmed and oiled, the surgeon, standing in front of the patient, passes it directly back to the pharynx, at the same time introducing the index finger of the left hand to guide its point over the epiglottis: it is then passed gently downward into the stomach. If any obstruction is met with in its passage, it should be withdrawn a little way and then pushed gently downward: all manipulations should be made without much force to prevent the perforation of the wall of the œsophagus.

The introduction of the stomach-tube may be required for the evacuation of poisons from the stomach or to wash out the cavity of this viscus, and it may also be used to introduce liquid nourishment into the stomach of patients who are unable or unwilling to swallow food. In the recently-introduced methods of treating disorders of the stomach and intestines by washing them out, *lavage*, the introduction of a stomach-tube is required; the tube here employed is from twenty-four to thirty inches in length (Fig. 108) and the fluid is introduced by means of a

Fig. 108.



The stomach-tube.

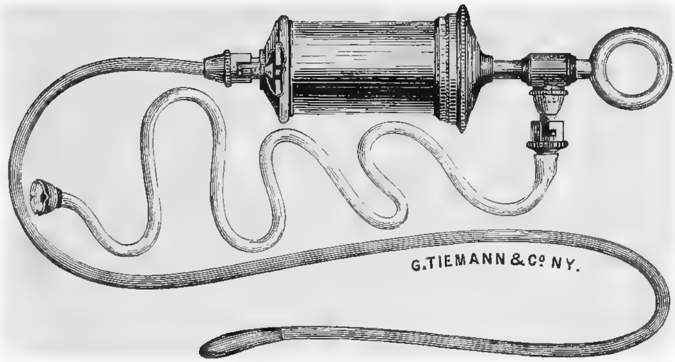
funnel attached to its free extremity, or the tube may be attached to a stomach-pump. In introducing liquid nourishment a syringe or funnel is fitted to the exposed end of the tube which has been passed into the stomach; the syringe or funnel having been filled with milk, beef tea, or broth, the contents are injected gently or allowed to run slowly into the stomach. In cases of poisoning, where it is desirable to withdraw the contents of the stomach and to wash out the organ, a stomach-tube and syringe may be employed; several syringefuls of warm water are first thrown into the stomach and then withdrawn by suction, and in cases of emergency this simple apparatus may be employed, but the use of the stomach-pump will be found more satisfactory.

The Stomach-pump.

This consists of a brass syringe, the nozzle of which is connected with two tubes, one at the end, the other at the side. The passage through the nozzle is regulated by a valve controlled by a lever. The nozzle of the pump is attached to the stomach-tube, and the end of the lateral tube is placed in a pan of warm water (Fig. 109). By raising the piston and opening the valve water may be drawn from the basin, and by closing the valve and depressing the piston it is passed through the stomach-tube into the stomach: when a sufficient quantity has been injected in this manner, by reversing the action of the valve the fluid is drawn out

of the stomach and discharged through the lateral tube into a basin. This manipulation is continued until the water returns clear and the stomach has been completely washed out.

FIG. 109.



The stomach-pump.

Œsophageal Bougie.

This instrument—which may be passed through the œsophagus into the stomach for the purposes of diagnosis or for dilating strictures of the œsophagus—is passed in exactly the same manner as the stomach-tube, and, as in the case of the latter instrument, it should be introduced without much force, as perforations of the œsophagus have followed the forcible introduction of such bougies.

Vaccination.

The surface may be prepared for the reception of the lymph by abrading the surface of the skin at one or two points with a dull lancet, or by making several superficial incisions, or by scratching the surface of the skin with the ivory point charged with lymph in lines with crossing lines, *cross-scratch*, until a little serum exudes. It is not advisable to draw blood, which washes away the lymph, and for this reason I prefer the abraded surface made by the dull knife or the ivory point.

The lymph employed may be the humanized or the bovine. The humanized lymph may be the viscid fluid taken from the vaccine vesicles on the eighth or ninth day, or the dry scab which separates when the wound is healed; if the latter is used, a small portion of it is rubbed up with water until it forms a mixture of creamy substance; this is rubbed into the abraded surface or the punctures. In using humanized lymph care should be taken to see that it is procured from a healthy subject.

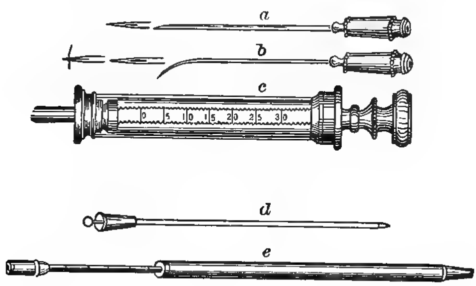
Bovine lymph or virus, which is now most generally employed, is taken from the vaccine vesicles upon the udder and teats of heifers; ivory points or quills are dipped into this lymph and allowed to dry, and in using them they are dipped in water for a moment, to moisten the lymph, before being applied to the abraded surface. The ivory point is one of the most convenient means of vaccinating, as the surface may be abraded with it before the lymph is applied.

It has recently been advised that antiseptic precautions be exercised in performing vaccination, and, although all of the details cannot be carried out, I have found that the exercise of care as regards cleanliness of the surface has been followed by much fewer inflammatory complications in vaccination-wounds. In performing vaccination the surface to be abraded, usually the left arm below the deltoid, is first washed with soap and water and then with a 1 : 2000 bichloride solution. Two points of this surface, an inch apart, are then abraded by using a knife which has been washed or dipped in boiling water, or by using the ivory point, which has been dipped in water that has been boiled and cooled down. When the surface has been prepared in the manner described moistened virus is rubbed upon it and allowed to dry. Vaccination upon the leg, which is practised by some physicians to prevent the scar from showing, is not always to be recommended, since it is more difficult to keep this part at rest, and some very severe cases of cellulitis and phlebitis have been observed following leg-vaccination.

Hypodermic Injections.

The syringe employed in making hypodermic injections is provided with a perforated needle, which is passed into the cellular tissue (Fig. 110). Care should be taken to see that the instrument and needle are

Fig. 110.



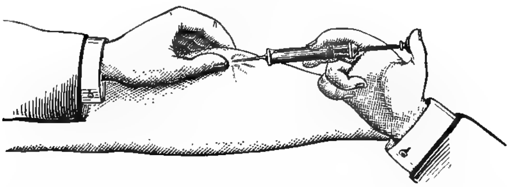
Hypodermic syringe and needles.

perfectly clean before being used: if a metallic syringe is employed, it should be rendered aseptic by soaking it for a few minutes in boiling water or in a 5 per cent. carbolic solution. Hypodermic injections are generally made into parts in which the cellular tissue is abundant, and great care should be observed to avoid introducing the needle into a large vein or artery, as by neglect of this precaution serious symptoms have resulted from the drug being thrown rapidly into the circulation instead of being slowly absorbed from the subcutaneous cellular tissue; injury to superficial nerves should also be avoided. Care should also be taken to see that the solutions employed are sterilized if possible, and freshly-made solutions should be preferred. An unclean syringe or a solution which has not been sterilized may give rise to a troublesome abscess at the seat of the injection.

To avoid using for hypodermic use solutions which undergo change from being kept, it will be found convenient to use the compressed pellets which are prepared by the manufacturing chemists, the alkaloids

being compressed with a little sulphate of sodium, which increases their solubility, the solution being prepared with boiled water just before being used. The portions of the body usually selected for hypodermic injections are the outer surface of the thighs or arms and the anterior surface of the forearm. In making a hypodermic injection the syringe is charged and the needle is fastened to the nozzle of the syringe; the skin is next pinched up and the needle is quickly thrust through this into the cellular tissue (Fig. 111): the syringe is then emptied by pressing down the

FIG. 111.



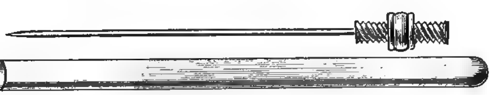
Method of giving a hypodermic injection.

piston, and when the syringe is empty the needle is withdrawn; the small puncture in the skin resulting seldom bleeds and usually heals without difficulty.

EXPLORING NEEDLE AND TROCAR.

The exploring needle consists of a fine-grooved needle fitted into a handle (Fig. 112), and is introduced into tumors or swellings to ascertain the nature of their contents.

FIG. 112.



Exploring needle.

The exploring trocar (Fig. 113) is employed for the same purpose, or the needle of a hypodermic syringe or a fine needle attached to an

FIG. 113.

Exploring trocar.

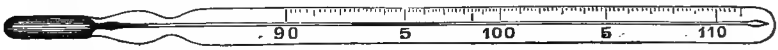
aspirator may be used for a like purpose. When either the exploring needle or trocar is employed care should be taken to see that it is rendered perfectly aseptic before being used; otherwise its employment is not without danger.

THE CLINICAL THERMOMETER.

For clinical observations two thermometer scales are in general use—the Centigrade and the Fahrenheit; the latter is the one commonly em-

ployed in America and England. This scale has a limited range above and below the normal temperature, which is $98\frac{2}{5}°$ Fahrenheit or 37° Centigrade. Thermometers are now made with a convex surface, which serves to magnify the column of mercury, and thus enables the observer without difficulty to note the position of the index (Fig. 114).

FIG. 114.



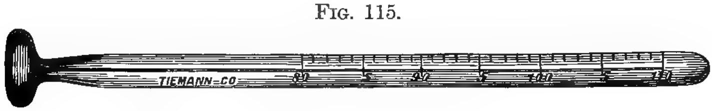
Clinical thermometer.

The temperature of the body may be taken in the mouth, axilla, vagina, or rectum; the two former positions are those generally employed. When taken in the axilla, care should be exercised to see that no clothing is interposed between the skin and the instrument, and when the mouth is used for thermometric observations, the patient should be instructed to keep his lips tightly closed and breathe through his nose. The thermometer should be kept in place from three to five minutes.

SURFACE THERMOMETER.

Surface thermometers are sometimes employed, the instruments for this purpose having bulbs of a discoid shape (Fig. 115) or are drawn out in the form of a spiral or coil.

FIG. 115.



Surface thermometer.

In using this form of thermometer to determine the amount of variation of the surface temperature, the temperature of corresponding parts of the body on the opposite side and the general temperature of the body should be taken at the same time.

THE RECTAL TUBE.

The introduction of the rectal tube is best accomplished by placing the patient upon his left side. The surgeon should introduce his index finger well oiled into the rectum and guide the tube upon this: if a stricture exists within reach of the finger, the latter should be used to guide the tube through the opening in this; if the tube becomes caught in a transverse fold of the mucous membrane and becomes doubled upon itself, it should be withdrawn and a fresh attempt should be made to pass it. In passing a rectal tube all manipulations should be made with extreme gentleness, since its passage is not without danger, perforations of the intestine having followed its use in some cases. In cases of stricture of the rectum high up the operator has to depend upon the sense of resistance experienced in passing the tube, and in such cases the manipulations should be most carefully made. When the rectal tube is employed to introduce fluids into the large intestine, the fluids may be

introduced by means of a syringe, or by pouring them into a funnel attached to the free end of the tube, or by attaching the tube to a fountain-syringe, thus allowing the fluid to pass slowly into the intestine.

The rectal tube is often employed with good results in relieving the intestine of excessive flatus and in introducing water or oil into the intestine in cases of intestinal obstruction, and in those cases where obstruction results from intussusception or fecal accumulations its use will often prove most satisfactory.

Rectal Bougies.—These instruments are made of the same material as the English flexible catheters and are of various sizes. Before being used they should be warmed and oiled, and then carefully introduced in the same manner as the rectal tube. They are generally employed in cases of stricture of the rectum, and they should be used with great care to avoid perforating the wall of the rectum. A very satisfactory substitute for a rectal bougie is a tallow candle, one end of which is melted or rubbed down to a conical shape.

Enemata.

An enema may be administered by means of an ordinary syringe or by means of a gravity or fountain-syringe, care being taken to introduce the nozzle of the syringe gently and in the right direction, as perforation of the lower portion of the rectum has taken place from the careless and forcible introduction of the nozzle of the enema-syringe; the fluids should also be injected slowly, as by so doing there is less resistance and less tendency for the patient to pass the fluid before the desired quantity has been introduced.

The enema most commonly employed to empty the lower bowel is made by adding a tablespoonful of sweet oil and two teaspoonfuls of spirits of turpentine to one or two pints of warm water in which a little castile soap has been dissolved; warm water and sweet oil are also frequently employed for the same purpose.

Glycerin Enema.—One or two teaspoonfuls of glycerin injected into the rectum or a suppository containing glycerin will often be found an efficient substitute for the larger enemata of water, but it is more liable to produce tenesmus.

Nutritious Enemata.—When it is found necessary to resort to feeding by means of the rectum care should be taken that the quantity is not too large, and that it is of such a nature as not to cause any irritation of the walls of the rectum, or it will not be retained; two ounces in the case of an adult is generally sufficient to inject at one time.

Peptonized milk or beef-juice, or the yolk of an egg beaten up with milk, is often employed, and any unirritating drug may be mixed with the enema and administered at the same time.

Massage.

Under the general term "massage" a variety of manipulations are employed with advantage in the treatment of surgical affections. These consist in *effleurage* (or stroking), *petrissage* (or kneading), *tapotement* (tapping or percussion), and *passive* and *active motion*. Another variety

of massage consists in pinching up the integuments and muscles, the latter singly or in groups, and rolling them gently between the thumb and fingers. Before applying massage to an affected part, if there be a heavy growth of hair it should be carefully shaved off, otherwise the manipulations will give the patient pain, and irritation of the hair-follicles, resulting in abscesses, will be apt to occur. The part should also be rubbed over with olive oil, vaseline, or cocoa-butter before and during the manipulation. Massage is often employed with advantage in the treatment of sprains and strains in their subacute and chronic stages, and it will be found of great service in the later treatment of fractures involving the joints or their vicinity, in restoring the motion of the parts, as well as in improving the nutrition of the muscles which have become wasted from disease.

Effleurage (stroking) consists in gently smoothing or rubbing the surface of the part with the palm of the hand from the periphery; distended veins and lymphatics are thus emptied and liquid transudation is removed from the tissues. In the early stages of inflammation stroking is first applied above the seat of disease in order to afford more space for the return currents; the inflamed part is approached by degrees, and when reached firm and gentle pressure is made upon it, thus forcing the fluids inward and promoting the absorption of exudations if they have already occurred.

Petrissage (or kneading) is applied by rubbing the parts circularly with the extremities of the fingers or thumb or the palm of the hand, and is indicated in cases of ecchymosis into subcutaneous cellular tissue or in cases of inflammatory transudation. Petrissage may with advantage be combined with effleurage when it is desirable not only to break up transudations, but likewise to hasten the removal of the resulting detritus from the tissues. The operator has to judge of the amount of pressure to be employed in this variety of massage by the nature and seat of the material to be gotten rid of and by the sensitiveness of the patient.

Tapotement (or percussion) is applied by tapping the surface of the affected part either with the tips of the fingers held in a row, or by a small india-rubber hammer, or by the ulnar border of the hand. Tapotement, it is claimed, has been used with advantage in neuralgia and peripheral palsies, and is thought to bring about good results by promoting the absorption of the exudations from around the affected nerves.

Passive and *active motion* consists in alternately flexing and rotating the limb to imitate the normal joint-movements. These motions should be carefully practised, and in cases of fracture should not be undertaken until there is quite firm union at the seat of fracture, or, if for any reason, passive motion is made use of before this time, the fragments should be supported while it is being employed. Passive motion associated with massage will often be found of the greatest value in the treatment of joints which have been immobilized for a time following sprains, fractures, or dislocations.

Muscle-beating.—This is a form of massage which is practised by the use of three elastic tubes fastened together near a handle to which they are attached, the size of the tubes and the length and thickness of the

material depending upon the different purposes for which the instruments are employed. Muscle-beating, when applied to the general surface, should not be made upon the naked skin: the parts should be protected by a thin covering of some kind, and the application is to be suspended as the sensation of moderate burning or an increase of surface temperature is felt by the patient. Muscle-beating has been recommended in cases of muscular ataxy, in stiffness of the joints following sprains or dislocations, in rheumatism, and in lateral curvature of the spine. It has the advantage of being a form of massage which the patient himself can often employ with advantage.

Electro-therapy.

The constant current, galvanism, is often made use of in the various paralytic conditions which accompany or follow surgical affections, being passed along the course of nerve-trunks to excite their conducting power or in neuralgic affections to act as a sedative.

Faradization.—Electricity in the form of the induced current, faradism, is often employed in surgical affections where the tonic and stimulating effects are chiefly desired: in cases of wasting of the muscles following fractures or sprains, in some forms of club-foot, and in lateral curvature of the spine the judicious use of the faradic current will often be found to be followed by the most satisfactory results. The current is applied in such a manner as to bring about contraction of the affected or wasted muscles, and thus improve their nutrition.

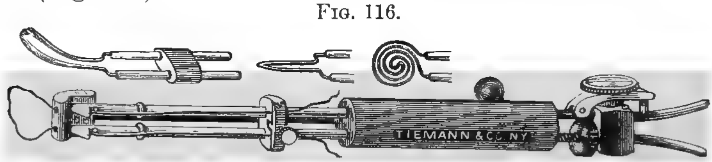
Franklinization, or Statical Electricity.—The earliest application of electricity in the treatment of disease was made by the use of statical electricity, and, although it fell into disuse, it has recently, with the perfection of modern machines, been very widely revived. In applying statical electricity the patient may be treated by insulation or the so-called dry electric bath. The second method of using statical electricity is by sparks or shocks from a Leyden jar which is charged from the prime conductor of an electrical machine in motion or by the electric brush. McClure states that in the static induced current we have a means of producing muscular contraction when failure results from the strongest bearable faradic currents.

Electrolysis.—Electrolysis, or the chemical decomposition induced by electricity, is employed in surgery to destroy morbid products, tumors, or exudations. For this procedure the galvanic or continuous current is required. In applying electrolysis to a tumor the needle connected with one of the poles of the battery is inserted into the tumor and the other rheophore is applied to the surface of the body, or two fine needles, carefully insulated nearly to their extremities, are connected with both poles of the battery by conducting cords; these are introduced into the tumor and a weak current is allowed to pass, and its strength is gradually increased as the operation advances; the current is passed for fifteen or twenty minutes, and the procedure is repeated at intervals of several days, until some decided change occurs in the tumor. Electrolysis has been applied with success in the treatment of aneurism inaccessible to other operative procedures, in malignant growths, in nævi, in goitres, cysts, hydatids, and is at the present time the most satisfactory method

of removing superfluous hairs from those parts of the body in which their presence causes disfigurement.

Galvano-cautery.—Galvano-cautery batteries are constructed with plates of large size, placed closely together, so that the internal resistance is reduced and a current is quickly obtained which will keep a metallic electrode at a white heat. The advantage in this form of cautery is that the electrode can be introduced into the various cavities of the body while cold, and quickly heated to the desired temperature. The electrodes are made of various shapes and sizes, according to the object desired (Fig. 116).

Fig. 116.



Electrodes for galvano-cautery.

Galvano-cautery is applied for the same purposes as the actual cautery, but, as previously stated, its use is more convenient in the various cavities of the body, its action can be more easily localized, and by its use hemorrhage is avoided. Galvano-cautery is frequently employed to destroy morbid growths in the nasal passages, the throat, vagina, or uterus, and also may be employed in the treatment of superficial external growths: in using it for the removal of growths from the mucous membrane its application may be rendered practically painless by previously thoroughly cocainizing the parts.

The Cystoscope.

This is an instrument for examining the mucous membrane of the bladder, and is one of the most important and useful of the electric-lamp instruments, because it affords information which cannot be obtained without it. A cystoscope consists of a beak sound in which there is a

Fig. 117.

Leiter's cystoscope.

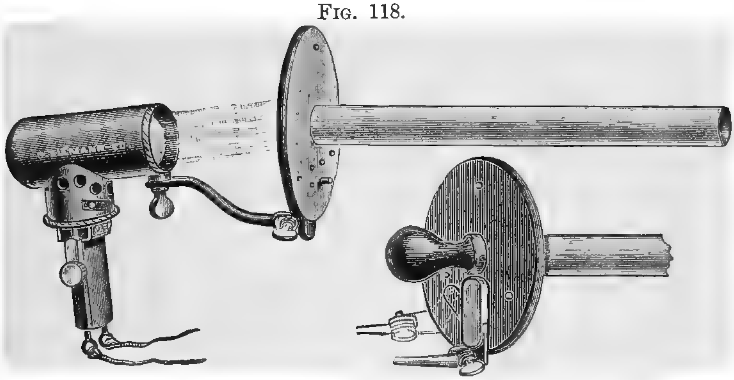
telescopic arrangement by which the surface of the bladder is viewed through a small window of rock crystal. The lamp is enclosed in the beak of the instrument and throws its light through another window,

also of crystal, upon the part of the bladder-wall. For examining the upper part of the bladder a separate instrument with a small reflecting prism is used. The bladder must contain six or eight ounces of clear urine or clear water if a proper view of the walls is to be obtained. If the fluid present is turbid, the view is very much obscured; if too little fluid be present in the bladder, the beak of the instrument with the lamp is likely to become buried in the folds of the mucous membrane and the light will be cut off, and in that case the mucous membrane may be burned. A certain amount of practice is required to use the cystoscope properly and to recognize the appearance of the mucous membrane of the bladder in health and in its varied morbid conditions.

The Urethroscope.

The urethroscope (Fig. 118) consists of a straight metal tube provided with a rounded obturator of hard rubber which projects beyond

Fig. 118.



The urethroscope.

the end of the tube. This instrument is introduced into the urethra until the bladder is reached, when it is slightly withdrawn and the obturator is removed. The instrument is then attached to a mirror or an electric lamp, by which a strong light is thrown into the tube, and as the tube is withdrawn various portions of the urethra are exposed to the view of the surgeon. By means of the urethroscope a very accurate inspection of various portions of the urethra can be obtained.

The Panelectroscope.

This instrument, introduced by Leiter, consists of a lantern with a handle and mirror. The light from a small incandescent lamp is projected by the mirror along the tube, which is inserted into the part to be examined. Tubes of various sizes are adapted to the instrument, and it is especially useful for endoscopy of the urethra, and it is also arranged for examining the ear, the pharynx, and stomach.

Local Anæsthesia.

Cold.—Local anæsthesia may be produced by the application of cold, either by a piece of ice or by a mixture of ice and salt held in contact

with the part for one or two minutes, or by directing a spray of rhigolene upon the surface of the part whose sensibility is to be obtunded.

Sulphuric ether, used as a spray for a few seconds upon the surface of the body, will produce complete anæsthesia. *Chloride of ethyl* is also used to produce local anæsthesia, and is conveniently furnished in glass tubes, one end of which is drawn out into a fine point and hermetically sealed; when used the end of the tube is broken off and a fine jet of ethyl is projected upon the surface, the warmth of the hand being sufficient to force the fluid from the tube. This form of local anæsthesia is made use of in minor surgical procedures, such as aspiration, the opening of abscesses, and the removal of superficial tumors.

Rapid Respiration.—Rapidly-repeated deep inspirations kept up for a few minutes will produce insensibility to pain, but sensibility to contact is not obliterated. This form of anæsthesia may be made use of in slight operations, such as the opening of abscesses.

Cocaine.—Local anæsthesia, produced by the employment of an aqueous solution of the hydrochlorate of cocaine, in strength from 2 to 12 per cent., is often made use of in minor surgical procedures where the mucous membrane is to be operated upon or growths removed from it. Analgesia is produced by brushing the surface over with the solution of cocaine or by applying a compress of absorbent cotton saturated with the solution to the part for a few minutes; in mucous cavities the latter method of application will be found most convenient. In using a solution of cocaine to produce anæsthesia in operations upon the eye a 2 or 4 per cent. solution is dropped into the eye, and the application is repeated until the analgesia is complete.

In applying cocaine to the urethra a 4 to 10 per cent. solution is injected into the urethra, and is allowed to remain for two or three minutes: more than one or two grains should not be injected at one time, for fatal results have followed the injection of larger quantities into this organ.

When it is desired to produce local anæsthesia of the skin or deeper tissues, the application of cocaine to the surface is not satisfactory, and it should in such cases be introduced hypodermically into the deeper layers of the skin and into the cellular tissues of the parts to be operated upon: to avoid multiple puncture the needle is not completely withdrawn from the wound, but its direction is changed, and the solution is thrown into the different portions of the tissues. It is well, in situations where it can be accomplished, to cut off the circulation from the part to be operated upon by placing around it a rubber strip or tube, which prevents its rapid absorption into the general blood-current. It is well not to inject more than one grain of the drug in that way, for fatal results have followed the injection of larger quantities, and great care should always be exercised in using cocaine hypodermically.

Some persons have an idiosyncrasy for cocaine, and children seem more susceptible to its constitutional effects than adults. The author has seen several cases in children in which marked symptoms of cocaine-poisoning have resulted from the application of a 4 per cent. solution to the nasal mucous membrane.

In minor surgical operations, such as amputations of the finger, circumcision, opening of abscesses, and the removal of superficial tumors,

cocaine anæsthesia may be employed with advantage, but its utility is most marked in operations upon the eye and those upon the mucous membrane of the nose, throat, rectum, vagina, and urethra. A 4 per cent. solution applied for a few minutes to the surface of an ulcer which is to be cauterized will render the operation almost painless.

Catheters.

Catheters are hollow tubes, made either of metal, india-rubber, linen and shellac, or other flexible substances.

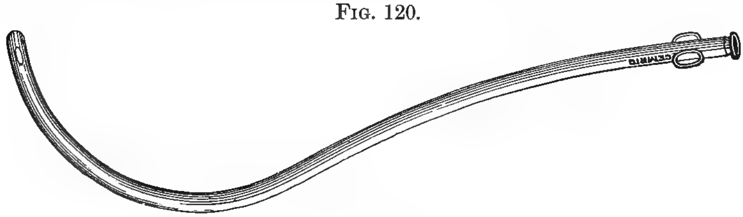
Metallic catheters are made of silver, or, if constructed of other metals, they should be plated with silver or nickel to give them a smooth, bright surface which can easily be kept perfectly clean; and their shape should conform to that of the normal urethra (Fig. 119).

Fig. 119.

Metallic catheter.

The shape of the metallic catheter is sometimes changed to meet certain indications; for instance, the metallic catheter for use in cases of enlarged prostate is longer and has a larger curve than the ordinary instrument (Fig. 120). The metallic catheter for the female is shorter and has a much smaller curve than the instrument used for the male urethra.

Fig. 120.



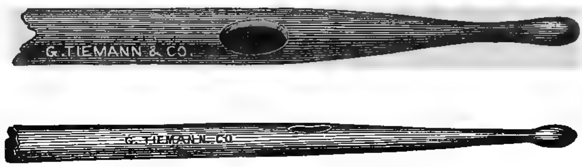
Prostatic catheter.

Flexible Catheters.—The most commonly used variety of flexible catheter is that known as the English catheter, which is made of linen and shellac, and is provided with a stylet; it can be moulded into any shape desired by dipping it in hot water, which renders it very flexible, and, after moulding it to the proper curve, this can be fixed by immersing it in cold water, which hardens it again.

The French flexible catheters are made of india-rubber or a combination of this material with other substances. These instruments are conical toward their extremities, and terminate in an olive-shaped point, and they are provided with one or two smoothly finished eyes near their vesical extremities (Fig. 121).

Another form of flexible catheter, known as the *elbowed* catheter or Mercier's catheter (Fig. 122), has an angle or elbow near its vesical ex-

Fig. 121.



French flexible catheters.

tremity; this is often found a satisfactory instrument to use in cases of enlarged prostate. A variety of flexible catheters made of soft india-rubber is also sometimes employed (Fig. 123).

Fig. 122.

Mercier's elbowed catheter.

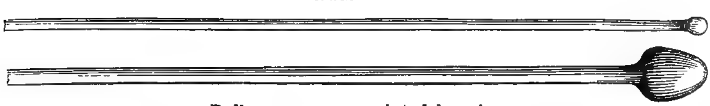
Catheters and bougies are made according to a certain scale. The English scale runs from 1 to 12, the American from 1 to 20, and the French from 1 to 30.

Fig. 123.

Soft-rubber catheter.

Bougies.—Bougies are flexible instruments which correspond in size and shape to the English and French catheters, and besides these are the acorn-pointed bougies (Fig. 124), and the filiform bougie, which is made

Fig. 124.

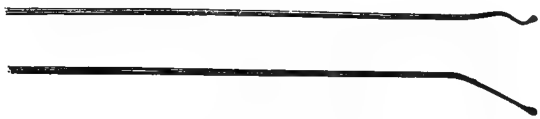


Bulbous or acorn-pointed bougies.

of whalebone or of the same material as the ordinary French bougie and catheter. Filiform bougies are of very small size, and can often be passed through strictures which will admit the passage of no other form of instrument (Fig. 125). Bougies are employed in the treatment of strictures of the urethra by dilatation.

Sounds.—Sounds are solid instruments made of steel with a smooth surface and plated with nickel; they correspond in size to, and have the

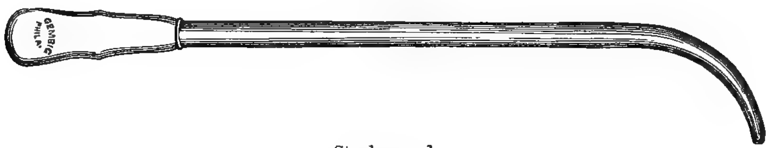
Fig. 125.



Filiform bougies.

same curve as the metallic catheter; the handle is flattened to allow the operator to grasp them firmly, and they are employed in the treatment of strictures by dilatation (Fig. 126). A special sound, which is straight

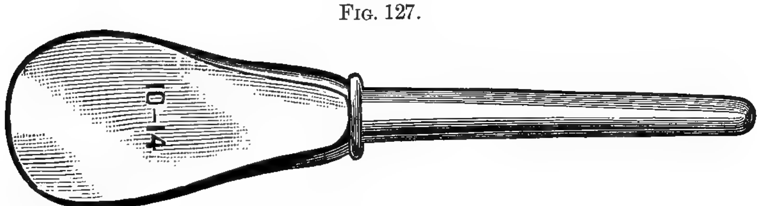
Fig. 126.



Steel sound.

and is shorter than the sound employed in the treatment of urethral strictures, is used in dilating strictures of the meatus (Fig. 127).

Fig. 127.

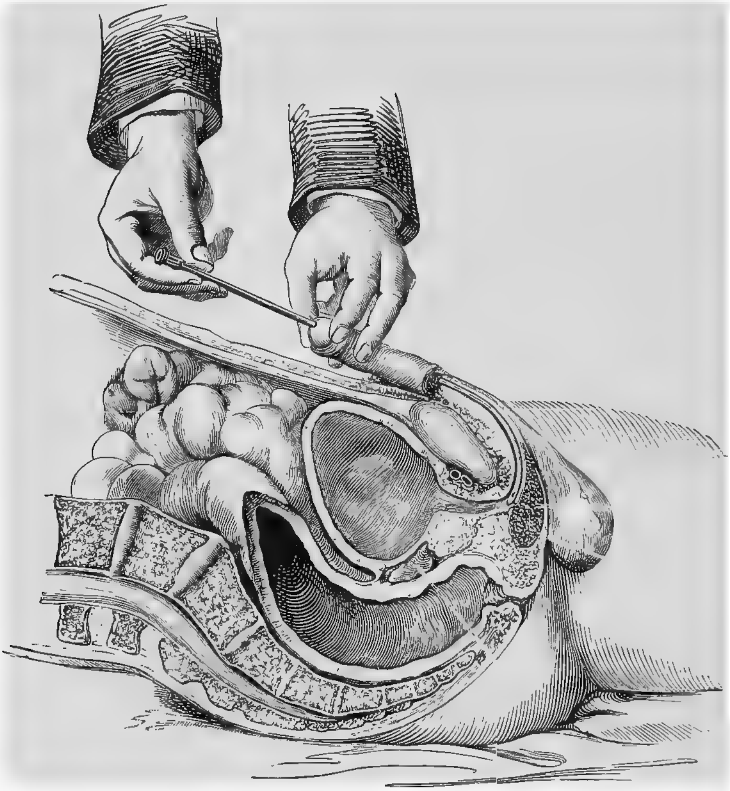


Sound for dilating meatus.

Introduction of a Catheter.—The passing of a catheter is a minor surgical procedure which every practitioner is at times called upon to employ, and in a healthy urethra it is a matter of little difficulty. For the introduction of a catheter the patient may be in the standing, sitting, or recumbent posture, and the latter is the best in most cases; he should rest squarely on his back and should have the thighs a little flexed and separated. Before passing a metallic catheter the surgeon should see that it is perfectly clean, and after warming and oiling it he stands upon the left side of the patient, grasps the penis with the left hand, and turns it over the pubis, introduces the beak of the catheter into the meatus, and gently passes it along the urethra until its point passes beneath the symphysis pubis; at this point the handle is elevated and gently depressed between the thighs, and the beak will pass into the bladder (Fig. 128). When the prostatic region is reached difficulty is sometimes experienced in passing the catheter; this is especially the case if the prostate gland is enlarged: this may be overcome by introducing the finger into the rectum and guiding the catheter through this

region, or if the prostate is very much enlarged the catheter should be withdrawn and a prostatic catheter should be substituted for it (Fig. 120). The same manipulation is made use of in passing metallic sounds.

FIG. 128.



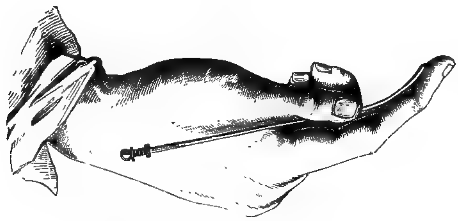
Introduction of catheter (Voillemier).

Flexible catheters and bougies are passed by grasping the penis and holding it in such a position that it is at a right angle to the axis of the body, and the catheter or bougie is passed into the meatus and carried through the urethra into the bladder by gently pushing the instrument downward. In this variety of catheter, which has no curve, the surgeon has no means of guiding the point of the instrument, and if an obstruction is met he should withdraw the instrument slightly and make another attempt; all manipulations should be extremely gentle.

Passing the Female Catheter.—This instrument should be introduced without exposure of the patient, she being in bed with the thighs slightly flexed and separated from each other. The surgeon introduces the forefinger of the left hand between the nymphæ, bringing it from behind forward until he touches the space between the entrance to the vagina and the orifice of the urethra; the catheter is then introduced with the right hand held as shown in Fig. 129, and, guided by the left forefinger, is passed through the orifice of the urethra into the bladder.

Tying Male Catheter in the Bladder.—When it is desirable to retain a catheter for some time in the male bladder, it is necessary to secure it to prevent its slipping out. Either a metallic or flexible catheter may be employed, but, as a rule, the flexible instrument is to be preferred. There

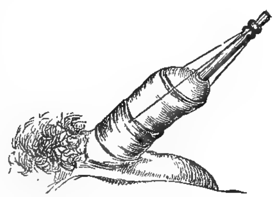
FIG. 129.



Method of holding female catheter.

are several methods of securing it in the bladder. One method consists in taking two narrow strips of tape, or two or three strong silk ligatures attached to the rings at the end of a metallic catheter or securely fastened around the end of the flexible instrument, and these are next brought backward, one on each side of the penis, and the skin is drawn forward, and a strip of adhesive plaster half an inch in width is passed over the ligatures or tapes and carried three or four times around the body of the penis just behind the position of the glans penis. If the skin has been brought well forward before the straps have been applied, the ligatures are tightened as it slips back, and the catheter has not too much play (Fig. 130).

FIG. 130.



Tying in catheter (Bryant).

Another method consists in fastening a strong silk ligature around the catheter just in advance of the meatus; the two ends are next brought backward and tied in a knot behind the corona glandis; the ends are then carried around behind the corona and tied on one side of the frænum; the foreskin is slipped forward and covers the ligatures.

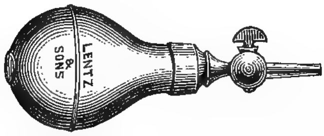
Catheters may also be secured in the bladder by tying the ends of the silk ligatures which are attached to the instrument in advance of the meatus to tufts of pubic hair. A simpler method of securing a flexible catheter is to perforate the free end with a needle armed with a double ligature of silk or hemp; the needle being removed, two loops are made of the proper length, and these are passed through the ends of a T-bandage, which is secured around the waist, the tails being brought up on either side of the scrotum and secured to the body of the bandage passing around the waist.

In the female bladder, when it is desirable to keep the bladder empty, the self-retaining catheter is employed, which consists of a catheter with a bulb at its vesical extremity, or an ordinary catheter with silk loops and a T-bandage may be employed in the same manner as in securing the male catheter.

Washing Out the Bladder.

This procedure may be required in the treatment of cystitis, and it is accomplished by passing a flexible catheter with a large eye into the bladder, or a double catheter may be employed. A syringe, or, better, a rubber bulb, holding about a pint, having a nozzle and stopcock (Fig. 131), is filled with warm water or with any medicated solution which is desired, and it is then attached to the free end of the catheter, and the contents are gently injected into the bladder; care should be taken that the bladder is not too much distended. When the desired amount of liquid has been injected, the bulb or syringe is removed, and the fluid is allowed to run out of the catheter, and the procedure may be repeated until the solution comes away perfectly clear.

Fig. 131.



Rubber bag with stopcock for washing out the bladder.

If it is desirable to have the bladder perfectly emptied of the solution, the operator should compare the amount of fluid injected with that which escapes, and in cases of paralysis of the bladder, where the fluid injected does not escape, gentle pressure should be made upon the abdomen over the pubis to facilitate its removal. Solutions of boric acid, permanganate of potassium, and weak solutions of carbolic acid and of nitrate of silver are often employed in washing out the bladder in cases of chronic cystitis.

Urethral Injections.

As urethral injections are usually made by the patient himself, he should be shown or instructed how to employ them. A rubber syringe having a conical nozzle and holding about two or three drachms is the best instrument to employ for this purpose (Fig. 132). The syringe having been filled with the solution, the patient, sitting upon the edge of a hard chair with the thighs separated, grasps the syringe between the thumb and middle finger of the right hand, the tip of the index finger resting upon the end of the piston, and inserts its conical nozzle from a quarter to half an inch within the meatus, which is held open by the thumb and finger of the left hand; and after its introduction the meatus should be drawn tightly around it, the pressure being made laterally so as to narrow the aperture instead of broadening it, as is the case when the compression is in an antero-posterior direction. After the fluid has been thrown into the urethra in this manner, the syringe is removed, and the patient is instructed to hold the lips of the meatus together for one or two minutes to prevent the escape of the fluid.

Fig. 132.

Urethral syringe.

Sutures.

A variety of materials are employed for sutures, such as silk, catgut, kangaroo-tail tendon, silver or iron wire, silkworm gut, and horse-hair; the material most frequently employed at the present time is either cat-

gut, silk, or silkworm gut, although some surgeons still prefer metallic sutures. Catgut and kangaroo-tail tendon are practically the only substances employed as sutures which are absorbent; other varieties of suture require removal after their application, although some sutures, such as silk or silkworm gut, when employed in deep wounds, may have their ends cut short, and, if the wound remains aseptic, they are apt to become encysted and produce no trouble. It matters little what material be employed for sutures if the surgeon is careful to see that it is thoroughly aseptic before being brought in contact with the wound.

Sutures of Coaptation.—These are superficial sutures applied closely together, and include only the skin; they are employed to secure accurate apposition of the cutaneous surface of wounds.

Sutures of Approximation.—These are sutures which are applied deeply in the tissues to secure approximation of the deep portions of a wound; this object is accomplished by the use of the quilled, button, or plate suture.

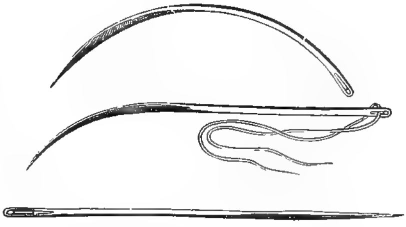
Sutures of Relaxation.—These sutures are entered and brought out at some distance from the edges of the wound, and are employed to prevent dangerous tension upon the sutures which approximate the edges of the skin. The quilled, button, or plate suture is suitable for this purpose.

Secondary Sutures.—These sutures are applied when the surfaces of the wound are covered by granulations, when the primary sutures have failed to secure apposition of the edges of the wound, or in cases of secondary hemorrhage where the opening of the wound has been necessitated to turn out the blood-clot and secure the bleeding vessel, or in plastic operations where the primary sutures have failed to secure apposition of the edges of the flaps. They are also employed with advantage in cases in which it is necessary to pack a wound with antiseptic gauze, or to allow hæmostatic forceps to remain clamped upon bleeding tissues in a wound at the time of operation. The sutures should in such a case be introduced and loosely tied at this time, and when the packing or forceps is removed at the end of two or three days the sutures are tightened so as to secure apposition of the edges of the wound.

Surgical Needles.

Needles for surgical use are of different sizes and shapes (Fig. 133): straight needles, triangular-pointed, are the ones most commonly employed, but curved needles will be found most convenient for the introduction of sutures in wounds of certain locations. The ordinary round sewing needle is the needle usually preferred in the introduction of sutures in intestinal wounds. Tubular needles are often employed in introducing sutures in wounds in which the use of an ordinary needle is difficult; for instance, in the operation for cleft-palate and for the introduction of sutures in deep wounds a mounted needle will often be found very useful (Fig. 134).

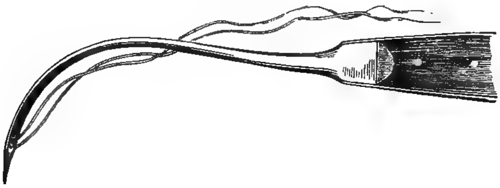
Fig. 133.



Surgical needles.

Calyx-eyed needles, which are threaded by being pushed down upon the suture, are sometimes useful. Hagedorn's needles, either straight or

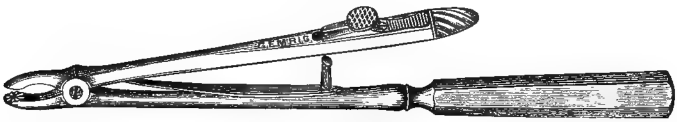
FIG. 134.



Mounted needle.

curved, which are flat and easily penetrate the skin and make a small clean wound, are often employed with advantage. Surgical needles should be sharp and clean, and should be rendered thoroughly aseptic

FIG. 135.



Needle-holder.

before being used. A needle-holder (Fig. 135) is often required for the satisfactory introduction of sutures in wounds of certain localities. If this is not at hand, the needle may be held by a pair of dressing forceps or a pair of hæmostatic forceps.

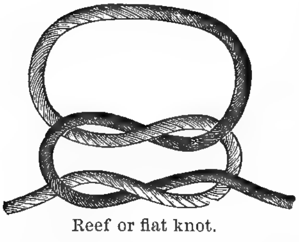
METHOD OF SECURING SUTURES AND LIGATURES.

Metallic sutures are usually secured by twisting the ends together or by passing the ends through a perforated shot and clamping the shot with a shot-compressor, which securely fixes them.

Sutures of catgut, silk, silkworm gut, kangaroo-tail tendon, or horse-hair are secured by tying, and several different knots are employed to secure them. These sutures may also be secured by clamping with perforated shot.

Reef or Flat Knot.—This is one of the best forms of knot to use in securing ligatures or sutures, and is made by passing one end of the thread over and around the other end, and the knot thus formed is tightened; the ends of the thread are next carried toward each other, and the same end is again carried over and around the other, and when the loop is drawn tight we have formed the reef or flat knot (Fig. 136).

FIG. 136.

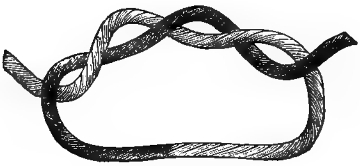


Reef or flat knot.

Surgeon's Knot.—This knot is formed by carrying one end of the thread twice around the other end, and after tightening this loop the same end is carried over

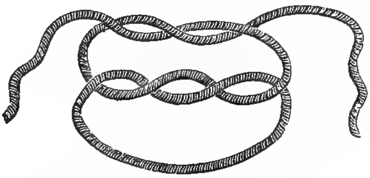
and around the other end, as in the case of the final knot of the reef or flat knot (Fig. 137). The surgeon's knot and reef knot combined form

FIG. 137.



Surgeon's knot.

FIG. 138.

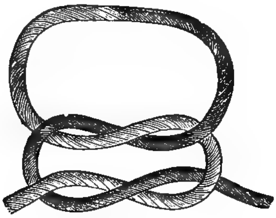


Surgeon's and reef knot combined.

one of the best methods of securing sutures or ligatures of catgut or silk, as the first knot is not apt to relax before the second knot is applied (Fig. 138).

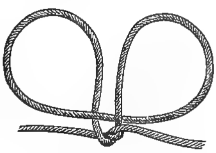
Granny Knot.—This method of tying the ligature or suture should not be employed, as the resulting knot is not as secure as the reef knot, and is apt to relax: it differs from the latter in the fact that, one end of the thread having been carried across and around the other end, the knot is completed by carrying the same end under and around the other end of the thread (Fig. 139).

FIG. 139.



Granny knot.

FIG. 140.



Staffordshire knot.

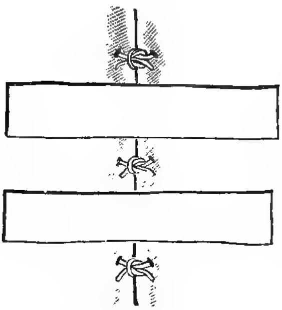
Staffordshire Knot.—This knot is much used to fasten the ligatures securing the pedicle in the removal of the ovaries or ovarian tumors; it is applied as follows: A mounted needle armed with a stout silk ligature is passed through the pedicle, and then withdrawn so as to leave a loop on the distal side; this loop is drawn over the ovary or tumor, and one of the free ends is passed through it, so that one end is above, while the other is below, the retracted loop (Fig. 140). The ends are then seized and drawn through the pedicle; at the same time the thumb and forefinger are pressed against it until sufficient constriction is made, and the ends are finally secured by tying as in the securing of an ordinary ligature.

VARIETIES OF SUTURE.

The Interrupted Suture.—This variety of suture is the one most frequently employed in the apposition of wounds, and consists of a number of single stitches, each of which is entirely independent of the others. In applying this suture the surgeon holds the edge of the wound with the fingers or forceps, and thrusts the needle, previously threaded, through

the skin three or four lines from the edge of the wound. He then passes the needle from within outward through the tissues of the opposite flap at the same distance from the edge of the wound (Fig. 141). A suture may be used with a needle threaded on each end, and in this case both needles are passed from within outward. The sutures may be secured as soon as applied, or they may be left unsecured until a sufficient number have been introduced, and then they may be secured by tying or twisting. Care should be taken to see that they make no tension on the edges of the wound, and that they are so introduced as to make the best possible apposition of the parts.

Fig. 141.



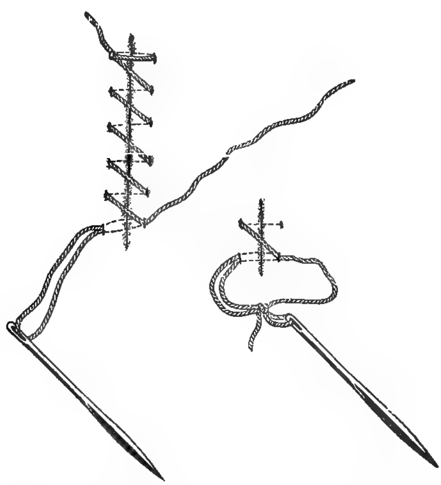
Interrupted suture.

Deep or Buried Sutures.—In extensive and deep wounds it may be found necessary to introduce both deep and superficial sutures, the former bringing about apposition of the muscles and deep fascia, the superficial layer bringing together the superficial fascia and skin.

The deep or buried sutures are often employed to unite fascia, muscles, or tendons, and the best material for this variety of suture is either catgut, silk, or silkworm gut.

Subcutaneous Suture.—Halstead has recommended a subcutaneous suture in which the needle is introduced on the under surface of the skin, emerging directly at its cut edge, which produces a subcutaneous suture, as the knot can be kept under the skin, and if the silk be fine and non-irritating it may be encysted or may be cast off after a time. The object of the subcutaneous suture is to avoid infection by the skin-coccus, which may be carried by the sutures if passed from without inward.

Fig. 142.



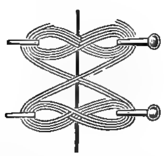
Continued or Glover's suture: method of securing.

Continued or Glover's Suture.—This variety of suture is applied

in the same manner as the interrupted suture, but the stitches are not cut apart and tied; it is made with silk or catgut, and is secured by drawing it double through the last stitch and using the free end to make a knot with the double portion attached to the needle (Fig. 142). This form of suture is often employed in intestinal sutures, or may also be employed in bringing about apposition of the edges of wounds in tissues of loose structure.

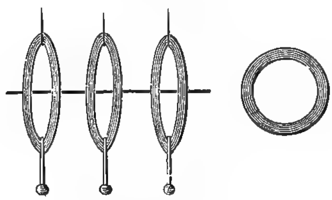
The Twisted or Hare-lip Suture.—This is a very useful form of suture where great accuracy and firmness of apposition of the edges of the wound are desired. It is applied by thrusting pins or needles through both lips of the wound, the edges being kept in contact over the wound by figure-of-8 turns of silk or wire (Fig. 143). The ends of

FIG. 143.



Twisted or hare-lip suture.

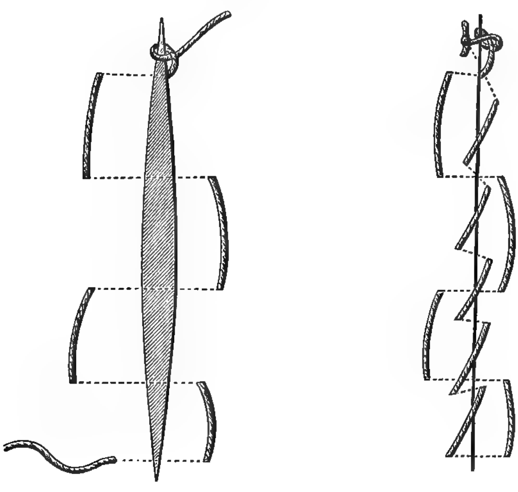
FIG. 144.



India-rubber suture.

the pins should be cut off by pin-cutters after the sutures are applied, or should be protected by pieces of cork or plaster to prevent them from injuring the skin of the patient and causing him pain.

FIG. 145.



The quilt suture.

The twisted or hare-lip suture is frequently employed in plastic operations about the face and in other parts of the body where accurate apposition of the parts is desired.

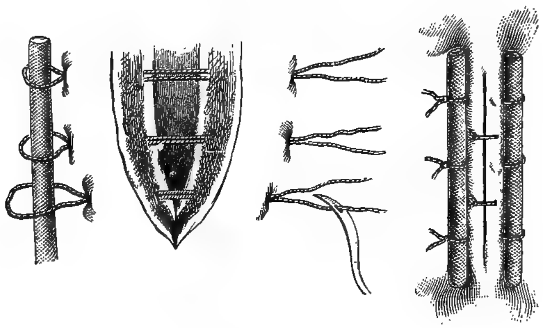
The India-rubber Suture.—This is applied by first passing the

pins or needles through the edges of the flaps, and, instead of the twisted figure-of-8 suture of silk, delicate rings of india-rubber are employed (Fig. 144).

The Quilt Suture.—This variety of suture is made with silk or catgut, and is employed in wounds to effect very close approximation of the parts and to prevent bagging; it is often employed in connection with the continued suture, and is applied as shown in Fig. 145.

The Quilled Suture.—In making use of this suture a needle armed with a double thread of wire is passed through the tissues, as in applying the interrupted suture, but at a greater distance from the edges of the wound. Into the loops on one side of the wound is inserted a quill or piece of flexible catheter or bougie, and on the opposite side the free ends of the sutures are tied around a similar object after being tightened (Fig. 146). This form of suture makes deep and equable

Fig. 146.

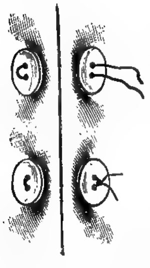


The quilled suture.

pressure along the whole line of the wound. In applying this suture it may be well in some cases to introduce a few superficial interrupted sutures along the line of the wound to secure accurate approximation of the skin. This form of suture was formerly much employed in cases of deep wounds to secure accurate apposition of the deep portions of the wound, but recently the introduction of buried catgut or silk sutures has largely supplanted the use of this variety of suture.

Button or Plate Suture.—This suture is applied by passing a needle armed with a double thread, as in the case of the quilled suture, the ends of the suture being passed through the eyes of a button or through perforations in a lead plate before being threaded in the eye of the needle. After the suture, prepared in this way, has been passed through both sides of the wound, the needle is removed, and the free ends of the suture are passed through the eyes of a button or the perforations in a lead plate on the opposite side of the wound, and are tightened and secured (Fig. 147). This form of suture may be employed in deep wounds to accomplish the same purpose as the quilled suture, and allows the cutaneous margins of the wound to remain free from compression; and here, as in the case of the quilled suture, a few interrupted sutures may be

Fig. 147.

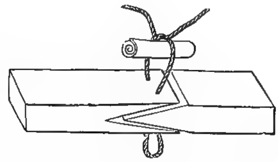


Button or plate suture (Smith).

introduced between the button or plate sutures to secure accurate apposition of the skin surface if desired.

Tongue-and-Groove Suture.—This variety of suture, devised by the late Dr. Joseph Pancoast, consists in slipping the margin of the flap, which has been bevelled, into a groove made by dissecting up the margin of the skin surrounding the raw surface which is to be covered. In applying this suture the wire or thread used has a needle applied on each end, and after passing the suture so as to secure the flaps the free ends are secured over a pad of adhesive plaster or a disk of lead or through the eyes of a button (Fig. 148).

FIG. 148.



Tongue-and-groove suture.

Shotted Suture.—This suture receives its name from the way in which it is secured: any of the previously mentioned varieties of sutures may be employed. After the suture has been passed the needle is removed and the ends are passed through a perforated shot; the ends are then drawn upon to bring the edges of the wound in contact, and the shot is pressed down to the skin and clamped by means of a shot-compressor. The suture is then cut off flush with the surface of the shot. This method of securing sutures is especially useful in closing wounds in mucous cavities, such as the vagina, rectum, and mouth, where the knot or twist of the wire might cause irritation of the surface or pain to the patient. It is also a useful method of securing sutures in plastic operations; it also facilitates the removal of the sutures, as the shot is not apt to be obscured by the swollen tissues, and is easily seized by forceps when the loop is divided.

REMOVAL OF SUTURES.—Where sutures are buried in the tissues or used to approximate parts in cavities which are subsequently closed, such material should be used for sutures as will be absorbed in a few days or will become encysted and remain harmless in the tissues—catgut, silkworm gut, kangaroo tendon, or silk; and it is needless to state that sutures used with this end in view should be rendered perfectly aseptic before being employed.

Chromicized catgut sutures, when well prepared and used in external wounds, usually undergo absorption in from ten to fifteen days; the loop buried in the tissues is absorbed, and the knot may be removed from the surface with forceps or comes off with the dressings.

Sutures made of other substances, such as silk, silkworm gut, silver wire, and horse-hair, are removed by cutting one side of the loop and making traction upon the knot of the suture with forceps, or in the case of the wire suture, after dividing the loop and straightening out one end of it, the wire may be withdrawn in a curved direction.

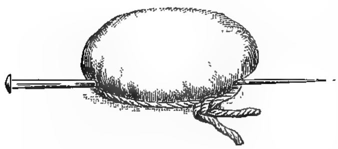
Sutures which are not causing any irritation should be allowed to remain in position until the wound is solidly healed. The time usually required for their retention in cases of aseptic wounds is from four to eight days.

LIGATURES USED FOR THE TREATMENT OF VASCULAR GROWTHS.

Various forms of ligatures are used for the strangulation of vascular growths, and the material used for such ligatures is usually strong silk or hemp thread, catgut, or silver wire.

Single Ligature with Pin.—This is applied by first inserting a hare-lip pin through the skin near the edge of the growth, passing it under the growth and bringing its point out through the skin at a point opposite the point of entry; a strong silk or hemp ligature, which has been well waxed, is passed under the ends of the pin surrounding the base of the tumor, and is drawn tight enough to strangulate the growth, and is secured by two knots (Fig. 149). If the growth is of considerable size, it is better before applying this ligature to introduce a second pin at right angles to the first one, and then secure the ligature under the pins. In applying these forms of ligatures to healthy skin the patient is saved much pain, and the separation of the mass is hastened, by cutting a groove in the skin with a sharp knife at the point where the ligature is to be applied; the ligature when applied is buried in the groove thus made.

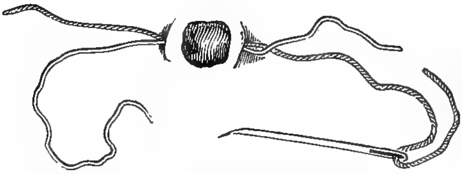
FIG. 149.



Single ligature with pin (Roberts).

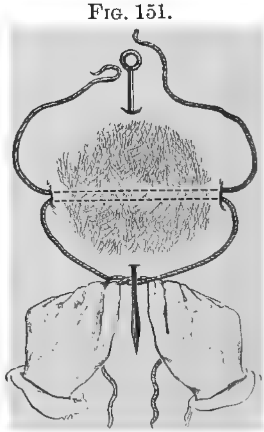
Double Ligature.—This ligature is applied by passing a needle or a needle with a handle, armed with a double ligature, through the skin near the growth, and then passing it under the tumor and bringing it out through the skin at a point directly opposite the point of insertion; the ligature is then divided and the needle removed, and the tumor is strangulated by tying firmly the corresponding ends of the ligature on each side of the tumor, each ligature strangulating one-half of the growth (Fig. 150).

FIG. 150.



Method of applying double ligature (Roberts).

FIG. 151.



Double ligature with pin (Bryant).

The double ligature may also be applied by first passing a pin under the growth, and then passing a needle armed with a double thread under the tumor at right angles to the pin, and after removing the needle the ends of the ligature are tied and the tumor is strangulated in two sections (Fig. 151).

Quadruple Ligature.—In applying this ligature two needles carrying a double ligature are passed under the growth at right angles to

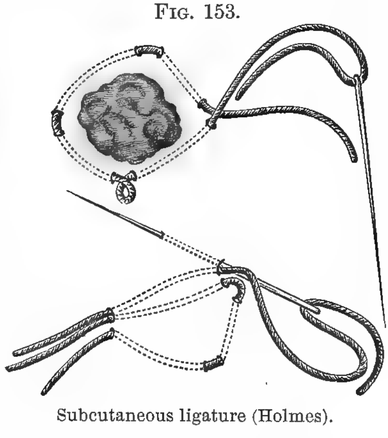
each other, or if the handled needles be used they may be first passed in this manner, and then threaded with double ligatures, which are carried under the growth as they are withdrawn. The needles being removed, the surgeon ties two ends of the ligature together, and repeats this procedure until the growth has been strangulated in four sections (Fig. 152).

FIG. 152.

Quadruple ligature (Liston).

Subcutaneous Ligature.—This is applied by introducing a needle armed with a ligature through the skin near the growth, and carrying it through the subcutaneous tissues around the growth for a short distance, then bringing it out through the skin. The needle is again introduced through the same puncture, and is again brought out through the skin at some distance from the first point of exit, and is next introduced through this puncture and brought out at a more distant point. In this way the growth is completely encircled by a subcutaneous ligature, which is finally brought out at the point of entrance; the tumor is strangulated by firmly tying the ends of the ligature (Fig. 153).

FIG. 153.



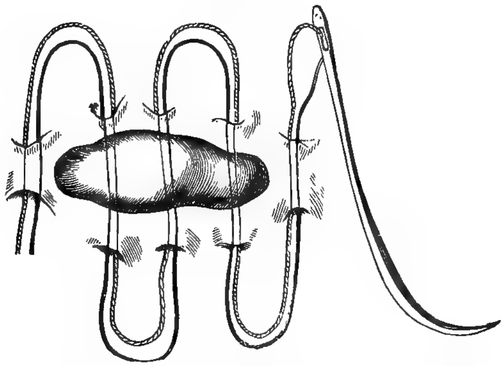
Subcutaneous ligature (Holmes).

If a needle armed with a double ligature is first passed under the growth, the ligature is divided, and by

passing each end of the divided ligature subcutaneously around the growth it may be strangulated subcutaneously in two sections.

Erichsen's Ligature.—This ligature is employed to strangulate tumors of irregular shape in a number of sections. A strong silk or hemp ligature, three yards in length, one-half of which is stained black, is carried by a needle as a double ligature under the growth at various points, so as to leave a series of loops about nine inches long on each

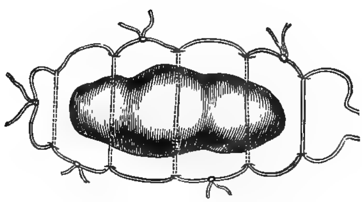
FIG. 154.



Erichsen's ligature (Erichsen).

side of the tumor (Fig. 154); the black loops being cut on one side, the white on the other, the ends are then firmly tied so as to strangulate the growth in sections (Fig. 155).

FIG. 155.



Erichsen's ligature applied.

Elastic Ligatures.—Ligatures made of india-rubber varying from half a line to several lines in thickness are often made use of in surgery. They may be employed to strangulate growths, such as moles or nævi, or in the treatment of fistulæ, and are especially useful in the treatment of those cases of *fistula in ano* in which the internal opening into the bowel is situated high up, as the division of such fistulæ by this means is accomplished without hemorrhage and with less risk than by the employment of the knife. In applying elastic ligatures in such cases the ligature, after being passed through the fistula by means of a probe, is carried out through the internal opening; the anus is next well stretched, and the elastic ligature is then firmly tied with two or three knots; the greater the tension made before the ligature is tied the more rapidly will it cut

its way out. The smaller sizes of rubber drainage-tubes may be substituted for the solid rubber ligatures.

General Treatment of Hemorrhage.

The surgeon may be called upon to treat the following varieties of hemorrhage: *arterial, venous, capillary,* or *parenchymatous;* and these are again classified, according to the time of their occurrence, as *primary,* that is, bleeding which occurs at the time the wound is inflicted; *intermediary* or *consecutive,* that which occurs within twenty-four or forty-eight hours after the reception of the injury, which generally takes place during the period of reaction; and *secondary,* which takes place after forty-eight hours, and may occur at any time subsequent to this period until the wound is healed.

The **treatment** of hemorrhage is either *constitutional* or *local.*

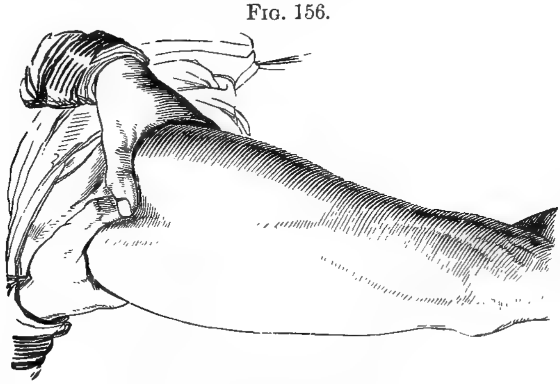
The *constitutional treatment* of hemorrhage consists in keeping the patient in the recumbent posture and avoiding any sudden elevation of the head or arms which might induce fatal syncope. Opium is a valuable remedy, and should be freely used. Ergot, gallic acid, acetate of lead, and tincture of iron may also be employed, stimulants and food should be carefully administered, and in extreme cases auto-transfusion or transfusion of blood or of normal salt solution may be resorted to.

In the *local treatment* of hemorrhage various measures may be adopted which may be either temporary or permanent in their action.

Temporary Control of Arterial Hemorrhage.—This may be effected by pressure applied directly to the bleeding vessel in the wound or by pressure applied indirectly to the main artery between the point of its injury and the centre of the circulation; and this pressure may be made by the fingers, digital compression, by compresses, or by means of tourniquets.

Digital Compression in Hemorrhage.—This constitutes one of the most valuable means employed in the temporary control of hemorrhage. The finger should be pressed directly upon the bleeding vessel in the

Fig. 156.



Digital compression of femoral artery.

wound or be used to make pressure upon the artery from which the bleeding arises at some point between the wound and the centre of the

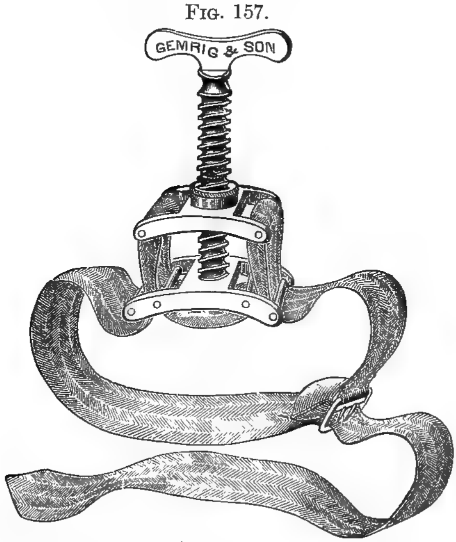
circulation (Fig. 156). Control of hemorrhage by digital compression can only be maintained for a few minutes, for the fingers of the surgeon or assistant soon become tired, so that it is only employed until means are adopted for the permanent control of the bleeding. Digital compression of the radial and ulnar arteries is frequently resorted to for the control of hemorrhage during amputations of the fingers, also of the axillary and femoral arteries in amputations at the shoulder- and hip-joints. Digital compression is also used to control hemorrhage from wounds either the result of accident or those made by the knife of the surgeon, in which case the finger is placed directly upon the divided vessel or is employed to hold a sponge or compress firmly in the wound.

Compresses.—By the use of compresses, placed directly in the wound or applied to the vessel between the wound and the centre of the circulation, the temporary control of hemorrhage may be very satisfactorily accomplished. Where it is possible the compress which is applied in the wound should be made of antiseptic gauze, thereby diminishing the chances of wound-infection. The compress should be held in position by a bandage firmly applied, and is generally employed only as a temporary expedient until a more permanent means of controlling the bleeding is adopted.

Tourniquets.—Tourniquets, which are instruments employed for the temporary control of hemorrhage from wounds, are of many different kinds.

Petit's Tourniquet.—Petit's tourniquet, which is the best for ordinary use, consists of two metal plates connected by a strong linen or silken strap, with a buckle, the distance between the plates being regulated by a screw (Fig. 157). In applying this tourniquet a compress or roller

Fig. 157.



Petit's tourniquet.

bandage is placed directly over the artery to be compressed, and may be held in position by a few turns of a roller bandage. The lower plate of

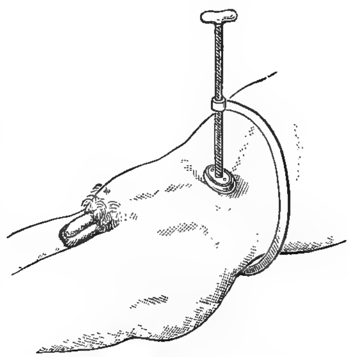
the tourniquet is placed directly over this pad, and the strap is tightly secured around the limb to keep the instrument in place. The screw is then turned so as to separate the blades and tighten the straps, thus forcing the compress or pad upon the artery, controlling its circulation. This instrument is very generally employed for the control of hemorrhage in wounds of the extremities, and it is especially useful in amputation of these parts, being placed over the main artery some distance above the seat of operation.

The Spanish Windlass.—An improvised tourniquet, known as the Spanish windlass, may be employed in the temporary control of hemorrhage in cases of emergency: it is prepared by folding a handkerchief or piece of muslin into a cravat and placing a compress or smooth pebble on the body of the cravat; this is placed over the artery to be controlled, and the ends of the handkerchief are tied loosely around the limb; a short stick is passed through this loop, and by twisting the stick the loop is tightened and the compress is forced down upon the artery (Fig. 158).

FIG. 158.

The Spanish windlass.

FIG. 159.



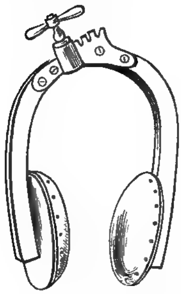
Lister's aorta-compressor.

Many other forms of tourniquet have been devised which have a pad or counter-pad so arranged as to make pressure upon the vessel desired, such as Lister's aorta-compressor (Fig. 159), which is employed in the treatment of aneurism of the iliac vessels and for the control of hemorrhage in amputation at the hip-joint. Hoey's clamp (Fig. 160) and Signorini's tourniquet (Fig. 161) are constructed upon the same principle, and are frequently employed to control the circulation in the femoral artery in case of operations upon the thigh and leg, and in the treatment of femoral or popliteal aneurism.

The elastic tube or *strap of Esmarch's apparatus* (Fig. 162) may also be employed for the temporary control of arterial hemorrhage, being applied above the wound, and if this is not at hand any strong rubber cord or a piece of large-sized drainage-tube may be used as a substitute. In hemorrhage from wounds of the hands and feet, especially in children, and in controlling hemorrhage in wounds of the penis, a piece of drainage-tube firmly applied above the wound may be employed with

advantage. This tube or strap, although generally employed to control hemorrhage from vessels of the extremities, may be used to control the

FIG. 160.



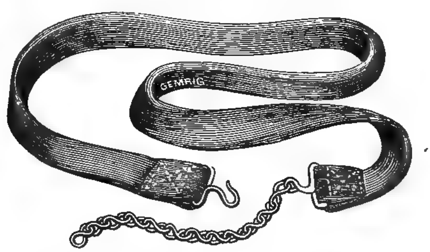
Hoey's clamp.

FIG. 161.

Signorini's tourniquet.

femoral artery as it crosses the brim of the pelvis by placing a compress over the artery in this position, and then applying the elastic band to

FIG. 162.



Elastic strap of Esmarch's apparatus.

secure it with a figure-of-8 turn, passing it under the thigh, crossing it over the pad, and then carrying the ends around the pelvis and securing them.

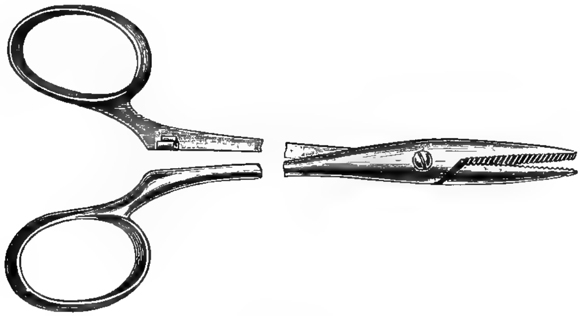
To make pressure on the axillary artery the compress should be placed in the axilla, and the middle of the tube is placed over this to hold it in position; the ends of the tube are then carried over the shoulder and crossed, and then carried to the opposite axilla and secured.

In amputation of the shoulder-joint, to make pressure upon the subclavian artery, which is difficult to compress by an ordinary tourniquet, the handle of a large key well padded may be used; it is firmly pressed against the vessel above the clavicle and held by an assistant, and proves a very satisfactory means of controlling circulation in this vessel. Wyeth's pins with an elastic strap or tube are now often

employed to control hemorrhage during amputation at or near the shoulder-joint.

Hæmostatic Forceps.—The temporary control of arterial hemorrhage by the use of hæmostatic forceps is now the common practice in surgical operations, and their use has done much to diminish the shock from the loss of blood following operations. The hæmostatic forceps

FIG. 163.

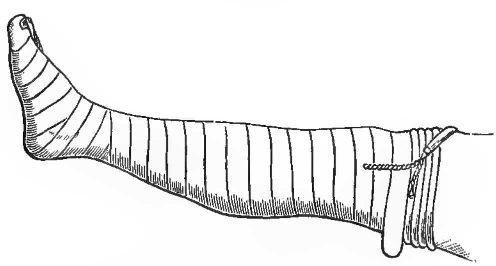


Hæmostatic forceps.

in general use is self-retaining; it is clamped upon the bleeding vessel, and is allowed to remain until the operation is completed, when the vessel is secured permanently by the application of a ligature and the forceps is removed. The use of this instrument will be found very satisfactory in controlling hemorrhage during the removal of tumors and in cases of amputation, and for the temporary control of bleeding during the operation of tracheotomy it will be found most efficient, as also in abdominal operations, in which its utility was first demonstrated (Fig. 163).

Esmarch's Bandage and Tube.—Esmarch's apparatus, which is applied to the limbs to render them bloodless during operations, consists of a rubber bandage two and a half inches in width and three or four yards in length, and a rubber tube two yards in length, to one

FIG. 164.



Esmarch's bandage and tube applied.

end of which is attached a chain and to the other end a hook, or, better, a rubber strap one inch in width and one yard in length, with a hook and chain. The bandage is applied to the extremity of the limb, and is

carried up the limb to a point some distance above the seat of proposed operation: the bandage is applied firmly, each turn overlapping one-fourth of the preceding one, and when the last turn has been made the rubber tube or strap is wound firmly around the limb, and is secured by fastening the hook into one of the links of the chain (Fig. 164). After securing the tube or strap the rubber bandage is removed from the limb, and if the tube has been firmly enough applied the limb will be found to be blanched, and should be free from blood during the operation. Care should be taken not to apply the tube or strap too tightly in poorly-developed limbs or on parts of the limb where large nerve-trunks approach the surface, as they may be subjected to an amount of pressure which will interfere with their functions subsequently: the writer has knowledge of one case of this nature in which permanent paralysis of the limb followed the use of Esmarch's apparatus. The tube should be applied with just enough firmness to control the circulation. As the strap, when firmly applied, completely cuts off the circulation of the parts below, it should be allowed to remain for as short a time as possible, as gangrene has resulted from its prolonged use.

After the removal of the tube there is generally quite free capillary hemorrhage, due to paralysis of vasomotor nerves from pressure, but this in a short time stops, especially if hot water is used to irrigate the wound. This apparatus is of the greatest service in controlling hemorrhage at the time of operation, and in amputations and removal of vascular tumors from the limbs will be found most satisfactory. In operations upon bone, either osteotomy or sequestrotomy, it is especially useful, as it allows the surgeon to have a view of the parts unobscured by hemorrhage. In operations for the removal of foreign bodies, such as needles imbedded in the hands or feet or extremities, Esmarch's bandage is most useful.

PERMANENT CONTROL OF ARTERIAL HEMORRHAGE.—For the permanent control of arterial hemorrhage the surgeon may resort to the use of position, cold, heat, styptics, pressure, cauterization, ligation, torsion, or acupressure.

Position.—In arterial hemorrhage from wounds of the extremities elevation of the parts will be found to materially diminish the amount of bleeding; in hemorrhage from wounds of the hand, forearm, foot, or leg forcible flexion of the forearm on the arm or of the leg on the thigh will be found useful in diminishing the force of the blood-current.

Cold.—The application of cold by means of a stream of cold water or of an ice-bag or piece of ice will often be found an efficient means of controlling arterial hemorrhage from vessels of smaller calibre; it is especially applicable to hemorrhage from wounds of the vessels of the mouth, nostrils, vagina, or rectum.

Hot Water.—Hot water will be found a very efficient means of controlling hemorrhage from small vessels, and it may be used in the form of a hot antiseptic solution. It is of especial value in capillary or parenchymatous hemorrhage; it is employed in the form of a douche or by means of sponges dipped in the hot solution and packed into the wound. Injection of hot water is the most satisfactory means of controlling uterine hemorrhage.

Styptics.—These agents are sometimes employed to control capillary

bleeding or hemorrhage from small vessels, but, although their use is found satisfactory as regards the control of the bleeding, they have the disadvantage of interfering with the primary union in wounds, and since the value of asepsis in wound-treatment has been demonstrated they are now very seldom employed. The most valuable styptics which are used are alcohol, alum, oil of turpentine, perchloride of iron, persulphate of iron (or Monsel's solution), acetic acid, or vinegar.

Pressure.—For the permanent control of arterial hemorrhage pressure may be applied directly to the bleeding point or surface by means of a compress of antiseptic or sterilized gauze or by strips of gauze packed into the cavity from whose surface the bleeding arises.

Compresses are used with the best results where the proximity of a bone gives a firm substance upon which the vessel may be compressed, as is the case in the vessels of the scalp. Pressure applied by means of packing with strips of gauze will be found most efficient in controlling hemorrhage from cavities such as the nose, vagina, or rectum, and in the cavities resulting from the removal of necrosed or carious bone. Pressure may be indirectly applied by flexing the proximal joint over a compress or by firm bandaging of the limb. In controlling bleeding from a divided artery in a bony cavity, such as the inferior dental canal, a piece of catgut ligature may be forced into the canal, and it will control the bleeding in a most satisfactory manner.

Halsted has recently introduced the use of a material known as *gut-wool*, which is prepared from the submucosa from which catgut is made; this is moistened with alcohol, and cut into fine shreds. The wool is preserved in an alcoholic solution of corrosive sublimate, 1 : 1000, and is used for stopping excessive hemorrhage from bone, a small quantity being pressed into the cavity or opening in the bone from which the bleeding arises.

The troublesome hemorrhage sometimes occurring after the removal of a tooth may be controlled by packing the alveolar cavity with a strip of sterilized gauze or by introducing a wedge-shaped piece of cork into the cavity and holding it in place by fastening the jaws together by means of a bandage.

Cauterization.—The use of cauterization by means of a hot iron is a satisfactory manner of arresting hemorrhage. Care should be taken to have the iron only of a dull-red or black heat, as the result desired is not the destruction of the tissues, but the coagulating effect of heat upon them. The form of cautery-iron employed will depend upon the position of the vessel. Paquelin's cautery is a very satisfactory apparatus to use for the control of hemorrhage.

Control of arterial hemorrhage by cauterization is often resorted to in operations upon the jaws and in the removal of tumors from the mouth or pharynx, or of the tonsils; it is also frequently employed to control hemorrhage in operations upon the uterus and the rectum, and also that resulting from the removal of abdominal tumors where the application of a ligature is difficult and often impossible.

Torsion.—This method of controlling arterial hemorrhage consists in seizing the end of the artery, drawing it slightly out of its sheath, and twisting it: it may be accomplished by a single pair of forceps or by two pairs of forceps. In the latter method the artery is held by one

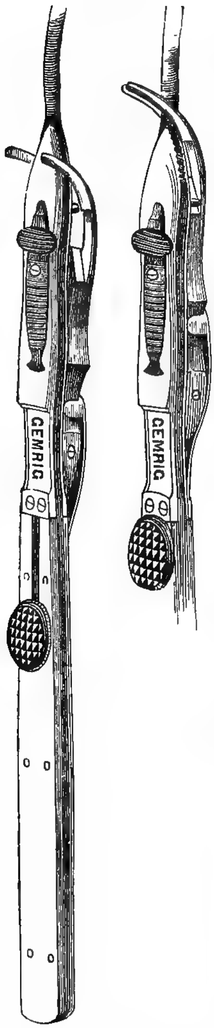
pair of forceps and twisted by the second pair. Torsion of arteries in accidental wounds is quite common, and in many cases controls the hemorrhage until surgical aid is rendered. The femoral artery in Scarpa's triangle has been completely controlled in this manner in the case of an avulsion of the thigh from railway injury. In vessels of moderate size it may be practised with one pair of forceps, and the ordinary double-

FIG. 166.

Double-spring artery forceps.

spring artery forceps (Fig. 166) or hæmostatic forceps will be found satisfactory for such cases. In larger arteries two forceps should be employed, or some of the numerous forms of torsion forceps (Fig. 165) which have been devised for this purpose.

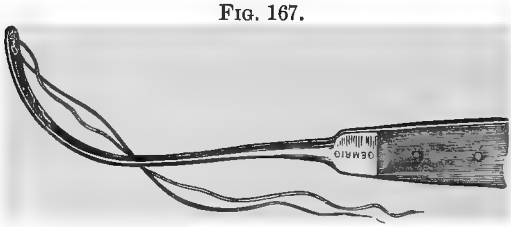
FIG. 165.



Hewson's torsion forceps.

Ligation.—The use of the ligature is by far the most generally employed method of controlling arterial hemorrhage. The materials used for ligatures are silk, hemp thread, catgut, horse-hair, iron or silver wire. Catgut or silk is the material most generally employed. The vessel is seized with a pair of artery or hæmostatic forceps or a tenaculum, and drawn out of its sheath, and a ligature of prepared catgut is thrown around it and secured by a surgeon's knot or by a reef knot and surgeon's knot combined, and when firmly tied the ends of the ligature are cut short

FIG. 167.



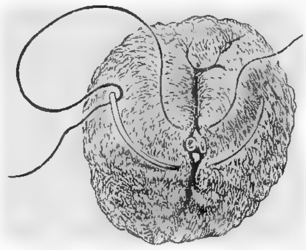
Aneurism needle armed with ligature.

in the wound. Silk ligatures which have been rendered aseptic are applied in the same manner, and the ends may be cut short in the wound.

When ligatures are applied to vessels in their continuity they may be threaded into an eyed probe or aneurism needle (Fig. 167), and carried around the vessel and secured. A convenient method of applying a ligature to a bleeding point in a deep wound or to a vessel in tissues which are of such a nature as not to permit of the isolation of the vessel,

is to use a curved needle threaded with a catgut ligature, which is passed deeply into the tissues near the vessel and brought out at the opposite side; the ligature thus placed is then firmly tied and the ends are cut short in the wound (Fig. 168).

Fig. 168.



Artery occluded by suture (Esmarch).

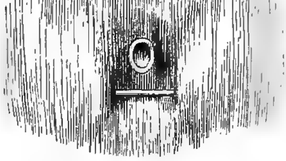
Constriction or Crushing of Arteries for the Arrest of Hemorrhage.—This procedure has been adopted for the closure of arteries without the use of ligatures or other foreign substances to be left in the wound. It was employed by the use of an instrument known as the *artery constrictor*, which grasped the artery and constricted it in such a way that the inner and middle coats gave way, but the external coat was preserved intact.

Arteriversion.—This method of controlling hemorrhage consists in constricting the mouths of arteries divided in amputations by turning over the cut ends with a little instrument called an *arteriverter:* with this instrument the ends of the divided arteries may be retroverted, and the cut extremity of the artery is reinforced by the duplicature of its walls, thus surrounding its open mouth with such a quantity of arterial muscular and elastic fibres as to effectually close it against the impulse of the heart's action. This procedure has been practised in a few cases, but has never come into general use.

Acupressure.—In this method of controlling arterial hemorrhage a needle or pin is used which is thrust through the tissues in such a way as to compress the artery. There are a number of methods of using the needle or pin.

First Method of Acupressure.—In this method the surgeon places a finger of his left hand upon the mouth of the bleeding vessel, and with his right hand introduces the needle from the cutaneous surface, and passes it through the thickness of the flap until its point projects for a couple of lines or so from the surface of the wound a little to the right side of the tube of the vessel. By forcibly inclining the head of the needle toward the right he brings the projecting portion of its point firmly down on the side of the vessel, and after seeing that it occludes

Fig. 169.



Acupressure—first method: raw surface (Erichsen).

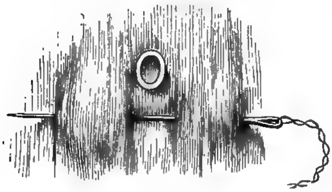
Fig. 170.

Acupressure—first method: cutaneous surface (Erichsen).

the artery he makes it re-enter the flesh as near as possible to the left side of the wound, and pushes the needle through the flesh till its point comes out again at the cutaneous surface (Figs. 169, 170).

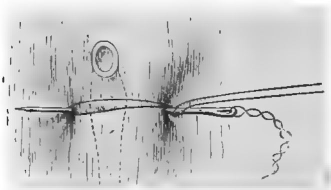
Second Method of Acupressure.—A straight needle threaded with a short piece of iron or silver wire, for the purpose of afterward retracting and removing it, is passed down through the soft parts a little to one side of the vessel; its point is then raised up and passed over the artery, and is then turned down again and thrust into the soft tissues on the other side of the vessel (Fig. 171).

FIG. 171.



Acupressure—second method (Erichsen).

FIG. 172.



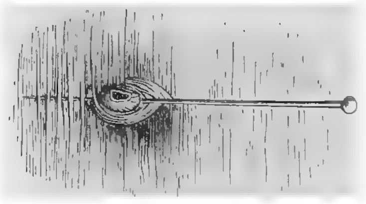
Acupressure—third method (Erichsen).

Third Method of Acupressure, or Filo-pressure.—In this method the point of the needle is passed into the tissues a few lines to one side of the vessel, then passed under it, and afterward pushed on, so that the point again emerges a few lines beyond the vessel. A loop of wire is next passed over the point of the needle, and then, after being carried over the vessel and passed around the opposite end of the needle, it is drawn sufficiently tight to close the vessel, and the ends of the wire are secured by making a twist around the stem of the needle (Fig. 172).

Fourth Method of Acupressure.—This method is identical with the third method, except that a long pin is used in place of the needle; the head of the pin remains outside of the wound.

Fifth Method of Acupressure, or Acutorsion.—This method consists in passing a pin or needle through the soft tissues close to the artery, and

FIG. 173.



Acupressure—fifth method (Erichsen).

by giving the pin a quarter or half rotation twisting the vessel upon itself, and fixing the pin by thrusting its point deeply into the tissues beyond (Fig. 173).

TREATMENT OF VENOUS HEMORRHAGE.

Bleeding from small veins often stops spontaneously unless there is some pressure upon the wounded veins upon the cardiac side of the wound. It is, however, very satisfactorily controlled by position, or by the application of a compress and bandage, or by the use of a ligature: if the divided vein be a large one, it is well to secure both ends of the

vein by ligatures. The free bleeding arising from ruptured varicose veins of the leg is easily controlled by a compress and bandage, while hemorrhage from the larger veins, such as the jugular, should be controlled by the application of ligatures as in the case of wounded arteries. The application of the *lateral* ligatures to small wounds of veins of large size, such as the femoral, jugular, or subclavian, or to wounds of the venous sinuses, has been recommended and employed with good results. It consists in pinching up the wall of the vein so as to include the orifice of the wound and throwing a delicate silk or catgut ligature around it and tying it firmly. The use of the actual cautery may also be required for the control of venous hemorrhage in positions in which its arrest by pressure or the ligature is not feasible.

Treatment of Capillary or Parenchymatous Hemorrhage.

Capillary or parenchymatous hemorrhage is usually arrested spontaneously by the exposure of the surface of the wound to the air, but it is often so profuse that its arrest becomes a matter of importance. To control this form of bleeding, pressure may be applied to the surface for a short time, and if this fails to arrest it, sponging the surface with dilute alcohol will sometimes prove satisfactory; but the best application to arrest hemorrhage of this nature is hot sterilized water or hot water, which may be used in the form of a hot bichloride solution. Acetic acid and vinegar are also sometimes employed for the same purpose. In cases where the means mentioned above fail to control the bleeding it may be necessary to pack the wound with strips of antiseptic gauze: this dressing is most serviceable when the hemorrhage comes from cavities, such as results from the removal of tumors or excision of joints; and for the control of bleeding following the removal of necrosed or carious bone packing the cavity resulting is the method very generally employed. To control hemorrhage from mucous cavities, such as the nose, rectum, and vagina, this method of treatment is sometimes resorted to.

Treatment of Secondary Hemorrhage.

Secondary hemorrhage following the use of the ligature or other means of controlling bleeding is, since the adoption of the aseptic method of wound-treatment, a much less frequent complication of wounds. The treatment of this complication is both constitutional and local. The constitutional treatment consists in the use of those remedies which were mentioned as serviceable in primary hemorrhage, and the drugs on which the most reliance is to be placed are opium and ergot. The local treatment of this form of hemorrhage consists in the use of the various means of controlling hemorrhage which have been mentioned before, such as the ligature, hot water, pressure, or the actual cautery. If possible, it is well to secure the vessel from which the bleeding arises in the wound. If for any reason this cannot be done, the main artery should be ligated at the point of election above the wound if the hemorrhage be arterial.

Rules for Ligating Wounded Arteries.

In case of primary hemorrhage the bleeding artery should be sought for and secured by a ligature. In applying a ligature to a wounded

artery the surgeon should cut directly down upon it at the point from which it bleeds, and secure it in the wound. This rule holds good for both primary and secondary hemorrhage.

Two ligatures should be applied—one to each end of the artery if it be completely divided, and one on each side of the wound if the latter has not completely severed the coats of the artery. This procedure is adopted for the reason that the arterial anastomosis is so free that the proximal ligature will not always, even temporarily, arrest the bleeding; and if it does accomplish this object at the time, after the collateral circulation is established bleeding is apt to occur from the distal extremity of the divided vessel. If the coats of the artery are not completely severed, their division should be completed either before or after the application of the proximal and distal ligatures, thereby favoring the contraction and retraction of the ends of the divided vessel.

PLASTIC SURGERY.

By GEORGE R. FOWLER, M. D.

Injuries and Inflammations of the Facial Region.

Wounds.—Owing to the vascularity of the parts, wounds of the face bleed freely. With the exception of some of the larger branches of the facial artery, however, the application of a ligature is seldom required. This same vascularity also explains the almost invariable occurrence of healing by first intention of wounds in this region. Even in tissues considerably lacerated and contused, sloughing is a rare circumstance. Nature's efforts are frequently successful in filling up defects, hence plastic procedures are best deferred until complete cicatrization takes place.

Burns.—Burns from hot water, caustic liquids, and chemical substances driven against the face in laboratory accidents are usually deeper than at first appear, and frequently involve an unfavorable prognosis so far as the cosmetic effect and function of the parts are concerned. In the case of the lower lip the saliva trickles away and the formation of labial sounds is interfered with. Ectropion of the lower eyelid permits the tears to flow over the face, and the globe of the eye suffers in consequence. Extensive formation of cicatricial tissue at the lateral aspects of the cheeks embarrasses the movements of the lower jaw. Operative interference is here demanded.

Gunpowder Accidents.—The presence of powder-grains in the skin of the face involves considerable disfigurement. When recent, the greater portion of them can be removed by vigorously scrubbing the face, under an anæsthetic, by means of a coarse and stiff hand-brush (Richardson). A stiff cataract needle applied to each powder-grain if the case is not seen until late will remove these in the course of time, although many sittings are required. According to Hebra, the prolonged application of a 1 per cent. solution of mercuric chloride is said to facilitate the extraction.

Simultaneous Wound of Skin and Mucous Membrane.—When both skin and mucous membrane are wounded at the same time, separate suture of the divided structures is required. This is particularly true of the eyelids. Perforating wounds of the oral cavity, if permitted to cicatrize, leave fistulous openings, through which liquids that are taken into the mouth escape, as well as the mucus and saliva. Stenson's duct may be involved in the injury, and the parotid secretion poured upon the outside of the face.

Traumatic Inflammation.—The extension of septic processes in the facial region are of rather infrequent occurrence, although the extensive vascularity of the soft parts would tend to favor such extension. This comparative immunity from spreading inflammatory conditions is mainly

due to the peculiar arrangement of the subcutaneous connective tissue, which passes directly at right angles to the surface to embrace the subcutaneous muscles. Although wounds in the neighborhood of these muscles gape widely, the peculiar arrangement of the connective-tissue fibres prevents propagation of septic inflammatory processes. In other parts, however—as, for instance, in the eyelids—the fibres of the connective tissue are arranged parallel to the fibres of the orbicularis palpebrarum, and phlegmonous inflammation is more apt to occur. Destruction of tissue here may give rise to cicatricial shortening of the integumentary surface of the lid, and consequent ectropion. Extension of the septic processes through the medium of the palpebral fascia and along the muscles of the globe or sheaths of the nerves into the mass of fat behind the globe inself, and thence through the superior or inferior orbital fissure to the brain, may occur.

A characteristic symptom of septic inflammation about the face is œdematous swelling of the involved parts. This is due, in part, to venous and lymphatic congestion, and in part to serous infiltration. Erysipelas infection likewise produces œdema. The occurrence of erysipelas in the face may lead to an extension to the scalp, and to the peculiar dangers which arise from the presence of infection in that region. Septic thrombi in the facial and orbital veins may give rise to serious metastatic pyæmia.

Although the facial region, therefore, is not particularly prone to inflammatory septic processes, yet in localities where it does occur serious results may follow. To add to the difficulties, the presence of the nares and mouth somewhat embarrasses the efficient application of antiseptic dressings. The application of collodion mixed with subiodide of bismuth or iodoform (Kuester), pencilled over the wound-edges along the line of coaptation, is here very useful.

Non-traumatic Inflammation.—Eczematous conditions of the skin of the face in children are of interest to the surgeon principally from the lymphatic glandular involvement near the angle of the jaw which is apt to follow.

In addition to ordinary bacterial infection, the integument of the face is liable, through the open follicles, to invasion of the so-called *thread fungi.* The special varieties of inflammation caused by these ectophytes, such as favus, sycosis or mentagra, blepharadenitis, or inflammation at the ciliary margin, belong to the domain of dermatology.

Facial Erysipelas.—This disease was formerly relegated to the domain of internal medicine, under the belief that it was an idiopathic affection. The disease, however, depends upon the presence of a specific germ which finds its entrance into the depths of the skin probably through some slight fissure, excoriation, the site of an acne pustulata, or the follicular openings upon the nose, which are unusually large. Its course is similar to that observed in the case of wounds, and the same treatment is applicable.

Plastic Surgery.

Plastic operations are resorted to for the purpose of restoring in an artificial manner lost portions of the body by means of living tissues.

The skin forms the most essential material for plastic operative procedures upon the surface of the body. This structure is particularly adapted for this purpose by reason of its exceedingly rich blood-supply and numerous capillaries.

Heteroplastic operations consist of replacing defects by means of tissue taken from sources other than the individual in whom the defect occurs. In this are to be included transplantation from one individual to another, as well as from a lower animal to man. Investigations as to the practicability of the latter are still in progress, and the attempts thus far made are sufficiently encouraging in their results to justify a still further trial of the method.

Autoplastic operations consist in replacing the defect by means of tissue taken from the same individual.

The indications for plastic operations consist of defects resulting from—(1) congenital cleft-formations, such, for instance, as hare-lip, cleft-cheek, fissures of the hard and soft palate, extrophy of the bladder, etc.; (2) from injuries; (3) from thermic and chemical destructive action; (4) from diseased conditions, such as carcinoma, lupus, and syphilitic and tubercular ulcerative action; (5) from the removal of benign tumors, angiomata, etc.; (6) from cicatricial displacement or distortion of parts resulting from inflammatory cicatrizing processes. In the latter class of cases plastic operations are demanded not so much because of loss of substance as from disturbances of shape and function of parts.

The indications may be further divided into those of a *cosmetic* and those of a *functional character*. In the former the patient's own choice usually governs, to a great extent, the surgeon's decision as to the advisability of operating; in the latter he will be in a position to directly advise the patient as to the best course to be pursued. There are also instances in which both cosmetic and functional considerations enter into the question—as, for instance, in the case of ectropion of the eyelid.

The time for performing plastic operations will depend upon the character of the case, and particularly upon the cause of the defect. In the case of injuries the plastic replacement should be attempted at once, and by means of the part itself which has been removed. Portions of the nose, fingers, tongue, etc. should be replaced immediately and sutured in position. Where the parts have been considerably crushed or otherwise destroyed, however, replacement cannot be successfully accomplished. Cases are on record in which attempts at immediate suturing in position of parts cleanly cut off have been successful even after an hour or more has elapsed since the reception of the injury.[1]

The time for operative interference in *congenital defects* also differs, the decision of the operator being guided by the location of the defect, its interference with important functions, the strength of the child, etc. (Vide infra.)

When plastic operations are applied for the correction of defects resulting from *ulcerative processes* arising from such destructive diseases as syphilis, tuberculosis, etc., the local focus must at first be healed, both local and general measures being employed for that purpose. In cases

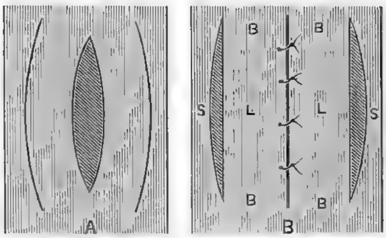
[1] Finney reports having successfully replaced the ends of the middle and ring fingers seven hours after they had been cut off (*Johns Hopkins Hospital Bulletin*, Baltimore, Oct. and Nov., 1892).

of *carcinomatous and other tumors,* if these can be thoroughly extirpated and healthy parts reached, the plastic operation best adapted to the conditions present may be at once proceeded with while the patient is still under the anæsthetic.

General Methods of Plastic Operations.

Two essential methods are employed. The first consists of *utilization of tissues from the immediate neighborhood;* the second, of their *transplantation from a distant part.* The first method may be again divided

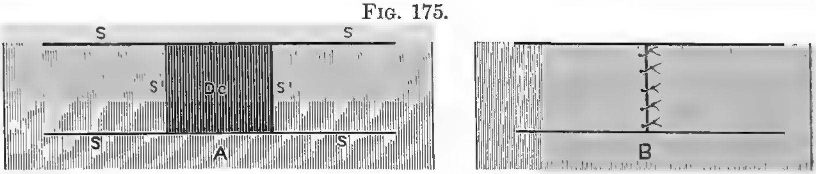
Fig. 174.



Relaxing incisions.

into those in which the tissues used to replace the defect are brought into position by sliding or lateral displacement, and those in which flap-formation and twisting of the pedicle are distinguishing features.

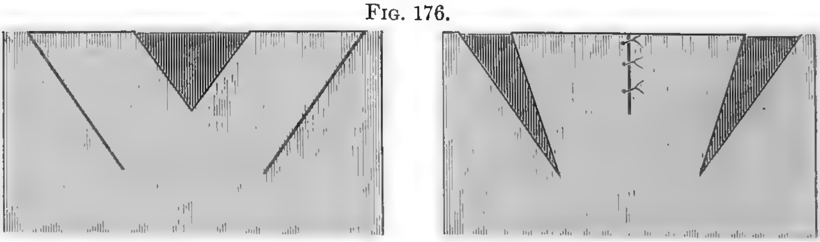
Fig. 175.



Closing a rectangular-shaped gap.

Replacement by means of lateral displacement may sometimes be accomplished without the introduction of new tissue, on account of the

Fig. 176.



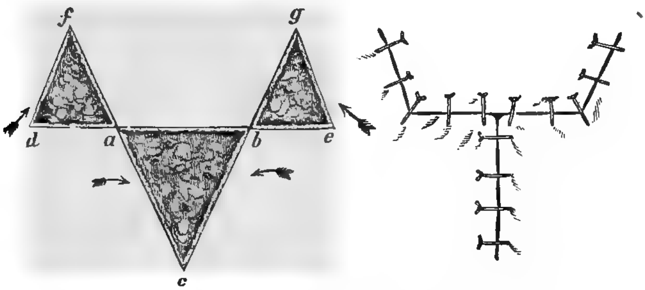
Dieffenbach's method of closing a triangular-shaped defect.

yielding character of the tissues. This may be aided by loosening the skin structures by means of more or less extensive dissection along the plane of subcutaneous connective-tissue space, or the employment of relaxing incisions (Fig. 174), made parallel to the intended line of

sutures, or both. These latter are permitted to heal by granulation. A method of closing a rectangular-shaped defect is shown in Fig. 175. Dieffenbach's procedure for closing a triangular-shaped defect is shown in Fig. 176. The method of Dieffenbach was still further improved by Bruns.

Bruns' Method.—Bruns' operation for the closure of large triangular defects is carried out as follows: Two lateral incisions are made (*d a*, *b e*, Fig. 177), the edges of the defect, *b c*, *a c*, freshened, and the

Fig. 177.

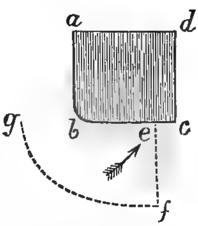


Bruns' method of closing a large triangular gap.

flaps, *d a c*, *e b c*, detached and brought together, the margins, *b c* and *a c*, uniting. The redundant tissue which is present at the angles, *a*, *b*, being removed, two triangular-shaped raw surfaces, *d f a*, *e g b*, are left, which are closed finally.

Lettenneur's Method of Closing a Quadrilateral Gap.—An incision (*b e*, Fig. 178) is made along the lower border of the defect, then downward to *f*, and finally, in a curved direction, to *g*. The space between *g* and *b* represents the pedicle of the flap. The latter is dissected from its attachments and displaced in an upward direction, the margin *e f* being sutured to *a d*.

Fig. 178.



Lettenneur's operation. The flap represented by the dotted lines should be proportionately larger.

Flap-formation with torsion is more frequently employed than the foregoing. The advantages of this method consist in—(1) its almost universal applicability; (2) the flaps can be more accurately adapted to the defect; (3) tissues free from disease can be selected for the purposes of repair; (4) by proper care in placing the pedicle nutrition of the parts may be more certainly assured. When the transplanted portion is taken from a distant part, the latter is approximated to the place of defect; under these circumstances torsion of the pedicle may or may not be employed. (See operation of Tagliacozza, p. 182.)

In order to secure the nutrition of the transplanted portions certain precautions are necessary. Death of these is less apt to follow the method of sliding than any other. In flap operations with torsion the flap must be sufficiently narrow, else the twist which it receives may result in undue pressure upon, and hence narrowing of, the vessels of supply. Among the precautions to be observed, the most important are the following: (1) The pedicle is to be located in a region from which a free

supply of vessels pass to the portion to be transplanted; (2) the formation of the flap must be accomplished with the greatest care, the edge of the scalpel being directed away from the skin, particularly when dissecting near the pedicle itself, in order to avoid injury to the latter; (3) an accurate isolation of the pedicle is necessary in order to permit of torsion without folding; (4) the pedicle must be sufficiently long to permit of an easy twist. The latter is to be further provided for by extending the incision which marks one boundary of the pedicle somewhat farther than the other, so that there is a long and a short edge to the latter, the long edge representing the margin or boundary *from* which the twist is turned.

In addition to these precautions, care must be taken that the raw surface of the flap fits closely upon the properly-prepared surface of the defect, and that the edges of the former are accurately sutured to those of the latter. All cicatricial tissue, if this is intended to be replaced by the transplanted portion, must be dissected entirely away, in order to obtain a normally vascularized surface for the reception of the flap. The chances of success will be very much enhanced by the employment of aseptic measures.

Plastic operations in the facial region are, as a rule, more successful than elsewhere, for the reason that here there is an exceptionally rich supply of arterial and capillary vessels. The tissues of the scrotum offer similar advantages. In regions where the vessels are less plentiful it is sometimes of advantage to loosen the flaps from the subcutaneous connective tissue, allowing them to be nourished by a pedicle at either end, packing beneath with gauze dressing material or oil-silk protective, and completing the operation at the end of a week, when a profuse granulating surface has been obtained. The newly-formed vessels increase the nutrition of the flap. One of the pedicles is severed, and the edges of the flap and defect freshened when approximation is effected. This method is called *transplantation of a granulating flap*. It is particularly useful in the operative treatment of extrophy of the bladder.

Elastic and *cicatricial shrinking* of the flap must be taken into account in planning plastic operations. The first named takes place at once, and amounts to about one-third of the entire area of the flap. It must be compensated for by an increase in the dimensions of the transplanted portion over the size of the defect. The second is to be guarded against by bringing the surfaces as accurately into apposition as possible, thereby securing primary union, rather than filling of an intervening space by granulation. In replacing a nose the newly-formed part must at first be largely in excess of the original nose, in order to allow for the very considerable shrinkage which inevitably occurs in the course of a few months.

Secondary shrinkage of the flap is prevented to a great extent by reinforcing the latter by means of the cicatricial tissues about the defect. For instance, in the case of a defect of the anterior and inferior portion of the nose the skin at the root of the organ is circumscribed by a horseshoe-shaped incision, loosened and turned downward, its raw surface corresponding to that of the flap taken from the forehead.

Under some circumstances the underlying periosteum may be employed as a portion of the transplanted structures. In the operation of

uranoplasty this is imperative, and also where cicatricial tissue must be utilized, the vessels between the cicatrix and periosteum being carried along with the flap.

The *circulation in the flap* may be retarded by the formation of coagula. It is better to have a rather pale than a bluish or congested flap, and in order to prevent the latter it is advisable to permit the flap to empty itself of blood before suturing it in position. In the case of a pale flap the normal color is restored in the course of twenty-four hours if all goes well.

At first the *sensation in the transplanted portion* is referred to the part from which the flap was taken. In the course of time, however, restoration of normal conduction of sensation occurs.

Complete separation and transplantation of larger flaps dissected from the subcutaneous connective tissue are now rarely practised, on account of the frequent failure of nutrition and death of the flap. The method is largely replaced by those next to be discussed.

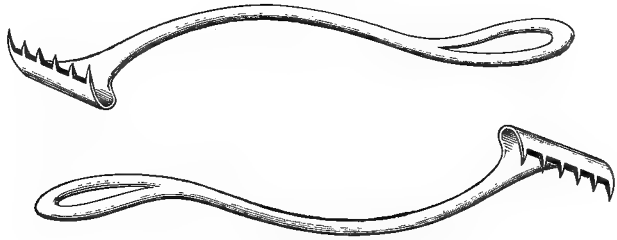
Reverdin's Method.—In 1870, Reverdin introduced the method which bears his name for the healing in of larger defects arising from burning, injuries, sloughing phagedena, and varicose ulcers. It consists of the implantation of small flat portions of epidermis, which are completely separated and which form islands upon the granulating surface of the defect. These soon become surrounded by a zone of proliferating epithelium. Although the transplanted epidermis is not very stable, the outermost layer being cast off and giving every appearance of failure, yet sufficient epithelial structure remains from which further proliferation occurs. In this manner the entire surface is finally covered. Small pieces for transplantation only should be used. Those of more than one, or at the most two, centimetres are apt to be followed by failure. The transplanted portions should be of skin only, and in order to better close the defect from which these are taken, when sufficiently large to require coaptation of their edges, they should be elliptical-shaped. Minute portions of skin when transplanted in this manner are sometimes employed, the process being called *skin-grafting.*

Thiersch's Method.—This consists in curetting or scraping away the granulating surface down to the solid base of the ulcer or other defect, and then implanting thereon strips consisting of the epidermal layer only. In this method the strips are shaved off by means of a razor, the part from which the strips are removed being made tense by grasping the circumference of the part or by means of specially-devised apparatus. The razor is laid flatwise upon the surface, and by to-and-fro or sawing movements a strip is obtained by splitting the skin in a direction parallel with its surface. These strips are from two to four centimetres wide and of varying lengths, according to the requirements of the case. To facilitate the removal of the strips it is necessary to render the skin tense at the point of proposed removal. The skin-stretching hooks of Dr. Charles McBurney are useful for this purpose (Fig. 179). Their method of application is shown in Fig. 180. A number of strips may be necessary to fill in the defect. The outer surface of the arm or thigh is usually selected from which to remove the strips.

Dressings, etc.—Skin-grafting should be accompanied by aseptic precautions; antiseptic fluids which coagulate the albuminous elements of

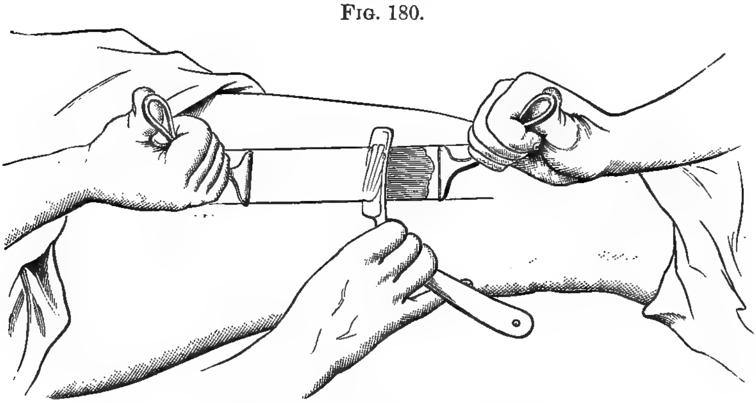
the tissues of the parts should not be employed. A normal salt-solution ($\frac{6}{10}$ per cent.) answers every purpose. Gauze dressings, as well as sponge materials, used at the operation should be wrung out of the same. After the strips are placed in position the site of the operation should be care-

Fig. 179.



Dr. McBurney's skin-stretching hooks.

Fig. 180.



Method of applying McBurney's hooks.

fully covered by narrow strips of oil-silk protective, arranged as in basket-strapping. Over this is placed a liberal supply of aseptic gauze, and the whole covered with sterilized non-absorbent cotton and secured in place by a roller bandage. The first re-dressing is done on the third or fourth day. Care should be taken not to disturb the transplanted portions of tissue.

Cicatricial Keloid following Thiersch's Method.—The secondary formation of cicatricial tissue beneath and between skin-grafts, resembling false keloid (Murray)[1] and giving rise to secondary contraction, is sometimes observed. This formation may take place when the grafting at first seems to be successful in every respect. According to McBurney, this is due to the too early abandonment of wet dressings, and he advocates that these be continued for two weeks following the operation. It is probable that the false or cicatricial keloid formation depends upon the causes which produce it under other circumstances.

Cicatricial Deformities following Burns.—The most important of

[1] *New York Medical Journal*, Feb. 4, 1893.

these are those of the face, neck, and upper extremities. The various methods of treatment, consisting of screw apparatus, elastic tension, weights, etc., as well as forcible rupture and total excision, even when followed by skin-grafting, save in cases of the simplest character, have been followed by only indifferent results. The various methods by flap operations have met with much better success.

Croft's Operation for Deforming Cicatrices.—This consists essentially in raising a flap of healthy skin adjoining the cicatrix, leaving it attached at both ends, but loosening it entirely in the middle, passing a strip of oil-silk protective beneath to prevent it from uniting to the subjacent tissue from which it has been elevated, and waiting until the process of granulation has been well established before proceeding further. When a granulating surface has been secured upon the raw surface of the strap-shaped flap, this is severed at one end, and the gap made by the division of the cicatrix and reduction of the deformity filled therewith.

The flap should be taken from structures well supplied with blood, and so placed as to be brought readily into its new position. Care should be taken to have the strap of sufficient length, and to prevent it from becoming unduly shortened prior to its transplantation by granulation tissue springing up in its angles during the two or three weeks that intervene between the two stages of the operation. The edges of the wound from which the strap was raised should be sutured together at once as far as possible. At the centre one or two sutures securing the parts to the muscles and fascia beneath will assist in preventing tension upon the sutures. The parts must be kept at rest, and the application of fixation apparatus will help to maintain this, particularly in young children.

At the second stage of the operation the contracting cicatricial structures are divided, the deformity reduced, and one end of the flap severed. The end retained as a pedicle should be that at which the vessels enter. The gap left by dividing the scar is to form a bed upon which the flap is to be placed. While this may be fashioned somewhat to correspond to the shape and size of the flap, yet an accurate adjustment of these is not possible nor even necessary. The flap, after being freed at one end, is trimmed, and about one-half of its raw surface toward the free end deprived of granulations by paring, in order to secure primary union between this and the fresh wound at the gap.

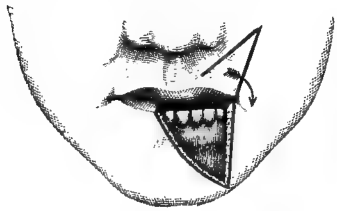
Primary union between the free end of the flap at the fresh wound does not always occur, in which case the flap must be maintained in position by strapping. Success will frequently follow even in these unpromising cases. When the implant has become firmly united it gradually flattens out and becomes broader. At least six months will elapse before the extent of the improvement can be estimated.

Cheiloplasty.

Estlander's Operation.—In cases in which it may be deemed desirable to replace the lost margin of the lower lip at once where the loss of substance is partial, is limited to one side, and the defect extends downward upon the chin, this method may be employed (Figs. 181, 182). A flap, the base of which is formed at the upper lip, is taken from the

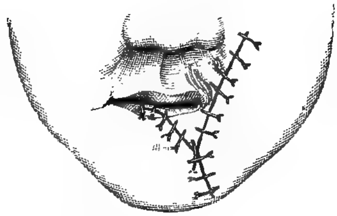
cheek and carried down to assist in filling the gap. If care is taken in shaping the flap, it will contain the superior coronary artery, which will aid in maintaining its nutrition.

FIG. 181.



A

FIG. 182.

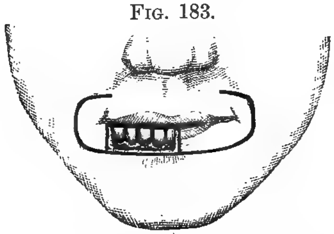


B

Estlander's cheiloplastic operation.

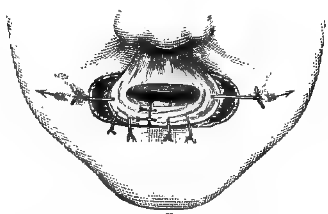
Langenbeck's Operation.—The incisions are a prolongation of the lower horizontal margin of the defect in either direction, and are curved around the angles of the mouth so as to extend into the upper lip. As much of the median segment of the upper lip as possible must be preserved consistently with the extent of defect to be closed, in order that

FIG. 183.



A

FIG. 184.

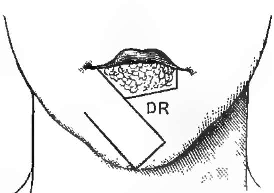


B

Restoration of the lower lip: Langenbeck's operation (after Löbker).

the communication between the coronary vessels and the arteries of the septum may not be disturbed. The portions of the lip thus included are drawn together toward the symphysis of the lower jaw, and there united by sutures, care being taken in finally closing the wound to fix the new

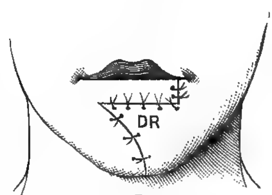
FIG. 185.



A

Lines of incision.

FIG. 186.



B

Appearance after suturing.

Langenbeck's operation for restoration of the lower lip (Hueter).

angles of the mouth in a position to preserve the normal outlines (Figs. 183, 184).

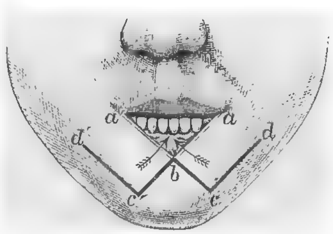
This operation is adapted for cases in which the loss of substance is limited to the free portions of the lip. In cases in which it can be car-

ried out it possesses, in males, the advantage that a beard can be grown in such a manner as to hide the line of union.

Method by Single Flap from the Chin.—When the defect to be filled is so great that the above method is not applicable on account of the diminution of the oral aperture which it involves, Langenbeck operated as follows: A flap is cut from the chin, with its base or pedicle directed upward and outward (*A*, Fig. 185). The edges of the defect are freshened, the flap detached and displaced upward, the triangular piece of skin, *DR*, serving to support the latter.

The Syme-Buchanan Method.—Two flaps are secured from the tissues of the chin. The edges of the defect are prolonged downward by two incisions (*a b c′*, *a′ b c*, Fig. 187), the flap being completed by the incisions *c d*, *c′ d′*. The flaps thus marked out are dissected from their attachments beneath, and turned upward in such a manner as to be united by sutures along the line *b c*, *b c′*. No effort should be made to close the triangular gaps, lest the margin of the new lip be brought to too low a level; this should heal by granulation. In this operation the point of the the chin is preserved.

FIG. 187.



Syme-Buchanan operation for restoration of the lower lip.

Bruns' Operation.—Special operative procedures are to be instituted in cases in which the disease is more extensively distributed. When the entire lower lip is involved, Bruns' operation, in which the defect is supplied from the cheeks, will replace the lost tissue (Figs. 188, 189).

FIG. 188.

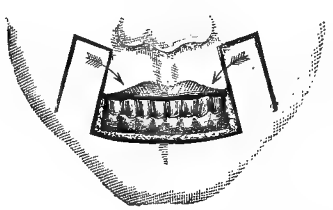
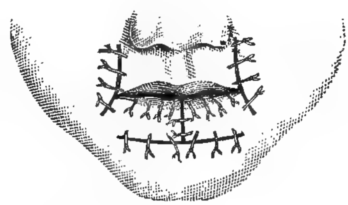


FIG. 189.



Bruns' operation for restoration of the lower lip.

As time passes, in this as in all plastic operations in this region in which the normal elastic lip is substituted by a flap with a cicatricial edge, the latter contracts, is drawn tightly against the lower jaw, and saliva trickles over the edge in spite of every effort to prevent it.

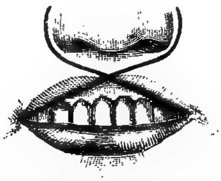
PLASTIC OPERATIONS UPON THE UPPER LIP FOR NON-CONGENITAL DEFECTS.

These are rarely required. In small defects operations based upon some of the plans already described for the lower lip will be found useful. Specially-devised procedures may be necessary in certain cases.

Dieffenbach's Operation.—This is employed where the central part of the upper lip is deficient and the edge of the defect covered with

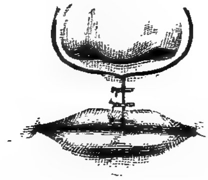
mucous membrane. Two flaps are marked out by two curved incisions which commence at the apex of the defect and are carried around the alæ of the nose (Fig. 191). These are dissected loose and brought together in the median line, the mucous membrane which formed the inferior margin of the flap having been preserved to form the free border of the restored lip (Figs. 190, 191).

FIG. 190.



Dieffenbach's operation for restoration of the upper lip.

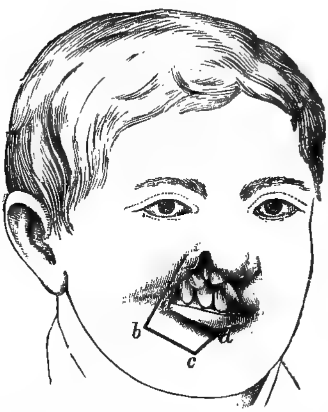
FIG. 191.



Dieffenbach's operation: the sutures applied.

Buck's Operation.—Gurdon Buck operated in a case in which one-half of the upper lip and a portion of the cheek had been lost, as follows:[1] The lower lip is divided by a vertical cut (*a b*, Fig. 192) one inch in length at right angles to the margin of the lip. A second incision (*b c*), commences at the lower end of the first, and is carried forward for about an inch and a half parallel with the margin of the lower lip. A third incision (*c d*) starts from the termination of the second, and extends obliquely upward for about half an inch or not quite to the lip. This attachment should not be encroached upon too closely, lest the nutrition of the flap be interfered with.

FIG. 192.



Buck's operation for restoration of the upper lip.

The sound portion of the upper lip is now to be dissected freely loose from its bony attachments, the edges of the defect carefully pared, and the flap from the lower lip brought into position and secured by suturing it to the freshened edge of the upper lip. The gap left by the flap is also sutured.

Serre's Operation.—This operation is intended to restore the angle of the mouth which has become distorted by a cicatricial contraction or removed in the extirpation of a growth. Three incisions are made. The first is horizontally placed; the second extends from the outer termination of the first obliquely downward, marking out a triangular space; the third and fourth form a second but smaller triangle. The bases of both triangles meet at the site of the new angle of the mouth (Fig. 193). When the gap which results from the removal of the tissues thus circumscribed is closed, the appearance shown in Fig. 194 is presented.

STOMATOPLASTIC OPERATIONS.—While cheiloplastic operations aim to replace parts lost by injury or disease, stomatoplastic operations are

[1] *Contributions to Reparative Surgery*, 1876.

designed to correct pathological mouth-formation. The indications are (1) macrostoma; (2) microstoma; (3) ectropion of the lip.

FIG. 193.

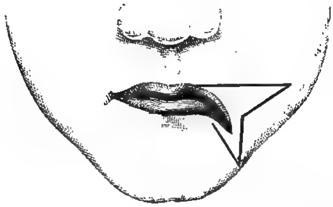
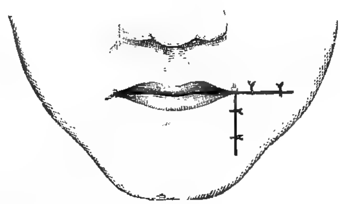


FIG. 194.



Serre's operation for restoring the angle of the mouth.

Macrostoma.—In case of congenitally large mouth the operation of freshening the edges of the cleft at the angles of the mouth and uniting the same is a simple procedure. There is usually no tension upon the parts, and union is rapid and complete.

Microstoma.—This is seldom congenital. Its most common cause is cicatricial contraction of the oral orifice following disease and injury. For its correction an incision is made for the necessary distance beyond the angle of the mouth, and "hemming" this with the mucous membrane from the lining of the cheek, which is loosened for this purpose. In order to prevent the incision from granulating together at the angle, toward the median line the incision is prolonged in a Y, placed horizontally at the angle, the mucous membrane of the cheek loosened more extensively at this point, and the triangular-shaped flap of mucous membrane is sewn to the new angle, as in Roser's method for phymosis.

Rudtorffer's Stomatoplastic Operation.—This consists of perforating the cheek at the point where the new angle is to be formed, and passing through the opening a metallic wire. When cicatrization of the opening is completed the usual incision is made from this point to the already existing oral opening, and hemmed with mucous membrane after Dieffenbach's method. The difficulty in obtaining cicatrization of the opening through which the wires are passed constitutes the chief objection to this method.

A tendency to recontraction following operations for microstoma may be overcome by having the patient wear an oval double-flanged ring, made of hard rubber, for an hour or more each day.

Ectropion of the Lips.—This occurs usually from accidental contraction of the mucous membrane of the lips. It is to be corrected by V-shaped excision of the cicatrix and Y-shaped union of the gap, as in ectropion of the eyelids. While this operation will correct simple cases, in severe forms cheiloplastic procedures are indicated. Separation of the labial edges from the cicatricial tissue, raising them to the proper level, and filling the resulting gap by a flap with a pedicle will prove successful in a certain proportion of cases.

Congenital Cleft Deformities of the Facial Soft Parts.

In the course of fœtal development the greater portion of the face is formed from the fronto-nasal process or arch. The latter consists of three

plates—the central or mid-frontal, and two lateral or cheek plates. The former develops in a downward and forward direction from the middle of the base of the skull, forming the nose and a portion of the upper lip. The lateral plates are separated from the mid-frontal plate by a furrow upon either side, which furrows form the primary nasal pits or fossæ. The latter are shut off from the rest of the face by the development and union of the lateral plates with the mid-frontal plate. The central part of the upper lip and the premaxillary bone (see Cleft-palate, page 163) are formed by the union of the lateral plates with the mid-frontal process. The lower margins of the thin plates form at the same time the upper limit of that branchial cleft the persistence of a portion of which forms the oral orifice. The presence of cleft deformities is to be attributed to a failure of certain processes or arches, formed during fœtal development, to coalesce and thus close the intervening gap or cleft. Those of the soft parts of the facial region consist of defects of the upper lip (hare-lip), fissures of the cheek, fissures of the lower lip, and fistulæ of the lower lip. (For Hare-lip see page 152.)

Fissure of the Cheek.—This is observed (1) as a vertical cleft; (2) as a horizontal cleft; (3) as an angular fissure. In isolated cases the edges of the cleft appear as scar tissue. In the majority of instances of the deformity the angle of the cleft is attached by a connecting bridge or frænum to the gums; exceptionally it is attached to the hard palate. Fissures of the cheek are sometimes present upon both sides, and occur simultaneously with other cleft deformities, as well as with congenital hypertrophy of the tongue (*macroglossa*).

Vertical fissure arises from defective union of the two lateral plates to the mid-frontal process. In extreme examples of the deformity the fissure reaches to the lower eyelid (*coloboma palpebræ*), the mucous membrane of the edges of the cleft joining that of the enlarged oral orifice,

FIG. 195.

Vertical fissure of the cheek (after Fergusson).

FIG. 196.

Horizontal fissure of the cheek (after Fergusson): an integumentary appendix is seen at A.

as well as the conjunctiva. The cleft may continue through the upper eyelid to the forehead (Hasselmann) or it may be connected with the nasal cavity (Verneuil).

Horizontal fissure is the result of failure on the part of the edges of the highest branchial arch to unite. An enormous enlargement of the mouth (macrostoma) is formed; the mouth may reach from one ear to the other. Skin appendices in front of the auricle are sometimes seen in connection with this deformity (*A*, Fig. 196).

Angular fissure is sometimes observed. Fergusson records an instance in which the cleft extended from the left angle of the mouth to the base of the lower jaw. A case is quoted by Beeley[1] in which the mouth was properly formed, but from beneath the left angle a cleft began which ran obliquely to the median line. The cleft was lined with mucous membrane and provided with a sphincter muscle. When the child's face was at rest the cleft appeared to be closed; when it cried the cleft gaped widely, and led into a hollow space lined with mucous membrane which lay between the cheek and the cavity of the mouth. A ranula was also present.

Congenital Deformities of the Lower Lip.

Median cleft of the lower lip is of very rare occurrence, from the fact that this structure corresponds to the second branchial arch, and therefore is developed as a whole from the first. It has been observed, however, by Ribel. Cleft of the lower lip occurring in connection with *cleft of the inferior maxillary bone and tongue* has also been observed (Parise).

Congenital fistula of the lower lip occurs with comparatively greater frequency than the foregoing. Fritsche has collected fifteen instances of the anomaly. In the majority of instances it has been associated with hare-lip. These fistulæ are lined with mucous membrane, and approach almost to the mucous membrane of the mouth, without, however, communicating with the latter. They may also take the shape of a *transverse fissure*, resembling a second oral orifice. *Trunk-like enlargement* of the lower lip has been observed in some cases.

Metoplastic Operations.

These operations are designed to correct defects in the soft parts of the cheeks. They are less frequently required than plastic procedures in other portions of the face, but are correspondingly difficult of execution in most instances. The skin of the neck and temporal region and of the forehead is employed for this purpose in complete loss of substance. The skin of the first- and last-named localities is that most frequently utilized: when taken from the neck the resulting scar may produce distortions of the head. Fortunately, complete loss of the cheek occurs very infrequently.

Schimmelbusch's Operation.—After the removal of the entire cheek for malignant disease the defect was filled in by means of flaps taken from both the neck and scalp. The flap from the neck reached nearly to the clavicle, and when turned up into position its skin surface replaced the buccal mucous membrane. The flap from the scalp when turned downward presented its raw surface to that of the neck-flap, while its outer hairy surface replaced the beard. Cicatricial contraction

[1] *Handbuch der Kinderkrankheiten*, vol. vi., Part II., p. 98.

is prevented by this method, and the movements of the jaw are not interfered with. The pedicles are divided in four weeks.[1]

In partial defects the particular procedure to be adopted will depend upon conditions present. Flaps with narrow pedicles are successfully employed on account of the rich blood-supply of the parts. In making these allowance must be made for possible distortions resulting from approaching too closely to the eyelids or lips to obtain large flaps.

The flap employed to correct a perforation of the cheek is apt to undergo contraction upon its buccal surface. In extirpation of growths from this region, therefore, the mucous membrane should be spared, if possible, for the reason that it is not easily replaced. Sliding of flaps of mucous membrane is not very successful.

Cicatricial lockjaw, following noma, presents one of the greatest difficulties in metoplastic procedures. Here the cicatrix must be divided and the gap filled in with double skin-flaps, the integumentary surfaces of which present, the one upon the side toward the cavity of the mouth and the other externally (Gussenbauer). In this manner recontraction, to a great extent, is avoided.

Hare-lip and Cleft-palate.

Congenital clefts of the facial region are the result of a failure to coalesce of the various fœtal clefts between the branchial arches in the cephalic extremity. The union of these arches, which should occur at about the ninth or tenth week of fœtal life, failing or occurring in an incomplete manner, various deformities follow, the chief of which are harelip and cleft-palate.

Hare-lip.—Hare-lip occurs very rarely in the lower lip, for the reason that the latter is formed, as a whole, from the mandibular or second branchial arch, which is complete from the beginning in the great majority of cases. Cases of *cleft in the lower lip* are reported by Ribel, and Parise reports simultaneous cleft of the inferior maxilla and tongue in addition to cleft of the lower lip. *Fistula of the lower lip* is sometimes observed associated with hare-lip in the usual location.

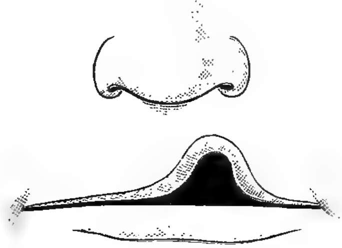
Varieties and Complications.—Hare-lip may be single, double, or complicated with cleft-palate. Almost without exception it is laterally placed in the line of one or the other naris. In rare instances a median cleft has been observed, but there are instances in which associated deformities are present, such as absence of the ethmoid, turbinated bones, nasal bones, vomer, and premaxillary bones. Single hare-lip occurs much more frequently than double (ten to one), and those upon the left side far outnumber those upon the right. In fact, arrest of development in general is said to occur upon the left side more frequently than upon the right.

Degrees of Hare-lip.—Three degrees of hare-lip are distinguished. The first is a mere notch (Fig. 197) passing but slightly beyond the vermilion border; the second extends to the nasal orifice, there terminating (Fig. 198); the third connects the mouth and corresponding nasal fossa into a common opening through the medium of the cleft (Fig. 199). The first two are, as a rule, uncomplicated, while the third is usually

[1] *Verhandlungen der Berliner med. Gesellschaft*, Dec. 1, 1892.

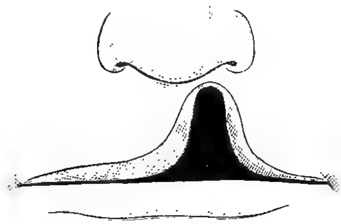
associated with cleft-palate and failure of union of the intermaxillary bone. This stage is frequently reached in single hare-lip; it is the rule

FIG. 197.



Hare-lip: first degree.

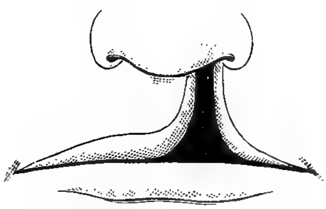
FIG. 198.



Hare-lip: second degree.

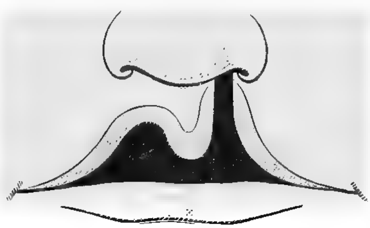
in the double variety, in which case two fissures of the alveolar arches are also present. The fissures in double hare-lip, in exceptional instances, may not both ascend to the same level, that upon one side being

FIG. 199.



Hare-lip: third degree.

FIG. 200.

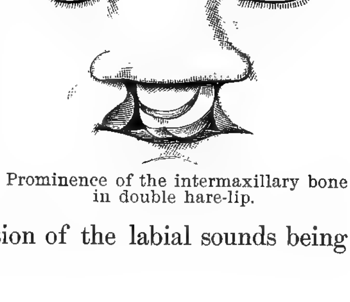


Hare-lip: complete upon one side and incomplete upon the other.

complete, while that upon the other may reach only the first or second degree (Fig. 200). In double hare-lip and cleft-palate the outer or premaxillary bone is separated from the alveolar arches. This bone carries the central incisor teeth; sometimes the number of the latter is in excess of the normal.

Double Hare-lip.—Double fissures, as a rule, do not pass beyond the cleft which separates the premaxillary bone from the alveolar arches, the vomer and palatine process of the superior maxillary bone joining upon one side. Even where this does not occur, and a double osseous cleft is present, but a single cleft of the soft parts covering the hard palate occurs. The prominence of the intermaxillary bone is produced by its freedom from restraint in double fissure, the growth of the vomer crowding it forward (Fig. 201).

FIG. 201.



Prominence of the intermaxillary bone in double hare-lip.

Various functional disturbances arise from the presence of hare-lip and cleft-palate. In cases of the former involving a lateral cleft to the first and second degree the cosmetic effect surpasses in importance disturbances of function, which are comparatively unimportant, the formation of the labial sounds being

alone interfered with. In complete fissure, however, grave disturbances may occur. Interferences with nutrition result from inability of the child to suckle properly, and bronchitis and pneumonia may result from the inspiration of air which has not been freed from dust and other irritating qualities by passing over a proper surface of normal mucous membrane. These dangers threaten particularly during the first year of life. In addition to the failure to produce labial sounds incident to cases of simple fissure, in those complicated by palatal cleft the air passes to both the nasal and oral cavities, and the voice assumes a nasal character, which interferes greatly with the formation of intelligible speech.

An hereditary predisposition to hare-lip has been suggested in view of the number of cases which have been observed to occur in the same family.

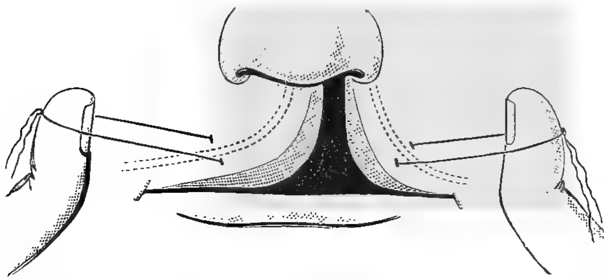
Operative Treatment.—In the operative treatment of hare-lip the time to be selected for the operation is of considerable importance. The French surgeons, as a rule, insist upon early interference in all cases. While many considerations impel the surgeon to correct the deformity as early as possible—notably those arising from the desire to calm the anxieties of the mother, as well as those referring to the dangers which threaten the child itself—on the other hand the condition of the child should be borne in mind. There are some very good reasons for counselling delay in weak and poorly-nourished infants, chief among which are, first, the fact that very young infants do not bear the loss of blood well at best, and, second, the gastro-intestinal irritation which is apt to be set up by the swallowing of blood will sometimes turn the scale against the child. Children, however, who have apparently thriven well upon the artificial feeding which is usually necessary may be operated upon at any time after they have become accustomed to the latter. Weak and ill-nourished children had best have the operation deferred for a few months, unless it is apparent from the conditions present that the malnutrition depends upon the deformity itself. As a rule, those with double hare-lip are deferred, other things being equal, until a later period than that selected for single hare-lip. A child of a year is none too old to bear well the operation for double hare-lip. Cases complicated with cleft-palate, whether single or double, should be operated upon not later than a year. With closure of the labial cleft the palatal defect during the succeeding few months grows narrower—an advantage which is manifest when the time comes for wearing a prothetic apparatus or closing the cleft-palate.

The Anæsthetic.—The question of the administration of an anæsthetic is to be carefully considered. While, on the one hand, anæsthesia permits a more accurate operative procedure, on the other a greater quantity of blood is swallowed, and inspired as well. In spite of this, the general preference is for chloroform anæsthesia. If the operation is performed without an anæsthetic, the child is wrapped tightly in a small blanket and fastened in a high chair, the chair, child, and all being tipped back so as to rest in the lap of the operator, sitting behind.

General Operative Technique.—In considering the general technique of the operative procedures for the cure of hare-lip the most important points relate to—(1) the prevention of hemorrhage; (2) the instruments; (3) the manner of making the incisions; (4) the relief of tension; (5) the sutures.

In former times special pressure-clamps for preventing hemorrhage were employed. The fingers of an assistant grasping the lip upon either side of the cleft serve the purpose much better, but these are somewhat in the way. An exceedingly useful device is to pass a loop of thread through the lip at a sufficient distance away from the edge of the cleft to be out of the way, and in a situation to control the bleeding from the coronary arteries (Fig. 202). This loop is given in charge of an assistant.

FIG. 202.



Temporary sutures controlling the coronary arteries and serving as retractors.

It need not be tied, as this would distort the parts; sufficient pressure can be made by simple traction upon it. The loop is to be removed as soon as the first one or two sutures are applied.

The necessary instruments are few and simple. A straight bistoury with a rather thin blade serves best for the formation of the flap. The edges to be freshened may be denuded with scissors, or the bistoury may be likewise here employed. Scissors, while they may be guided a trifle more accurately perhaps, produce more contusion of the parts. A pair of mouse-toothed forceps or a firm tenaculum to steady the flap as it is formed will also be needed. A pair of blunt scissors, curved upon the flat, and a half-dozen medium-sized and slightly-curved Hagedorn needles will also be required.

In making the incisions for the formation of the flap, as well as those for freshening the edges, the point of the knife is passed through the entire thickness of the lip, the edge being steadied by the forceps or tenaculum. The flap is to be cut after the manner described in the Nélaton, the Mirault-Langenbeck, or the Simons method. After fashioning the flap the edge of the flap toward the median line is freshened. In order to ensure firm union of the sutured edges the wound-surfaces are made as broad as possible. It is recommended by some surgeons, in order to accomplish this, to split the edges of the cleft in a direction parallel with the surface of the face, instead of or in addition to freshening them. The split edges are then broadened, the skin-surfaces being brought together from the edges of the cleft to form a fold without, and sutured, while the mucous surfaces are brought together to form a fold within, and likewise inverted. This procedure occupies more time, and involves additional risk in young and weak infants.

Before the sutures are applied the wound-edges must be relieved of tension when brought together, in order that the former may not cut through. For this purpose different incisions are made. The most

practicable, and the method involving the least loss of blood, consists in detaching with the scissors the lip from the gum, the scissors being made to follow the bone closely, and the tip of the left index-finger held in such a manner as to act as a guide, at the same time serving to lift the structures of the lip away from the upper jaw in an upward and outward direction. The scissors should be directed toward the superior maxilla throughout this entire dissection, and not toward the cheek, in order to avoid the vessels. The incisions are made on both sides, and the superficial bleeding arrested by pressure. The frænum of the upper lip is completely separated. These relaxation incisions heal readily. Their effects are at once manifest when the edges of the cleft are brought together. By their employment cheek-compressors, which fret and worry the child, can be dispensed with.

The first suture, in whatever operation chosen, should be applied in such a manner as to serve to arrest the hemorrhage, thus dispensing with the fingers of an assistant or the loop of thread employed for this purpose. For the rest, alternating deep or tension and superficial or coaptation sutures are to be applied. In addition, particular attention is to be paid to the accurate adjustment of the edges at the vermilion border.

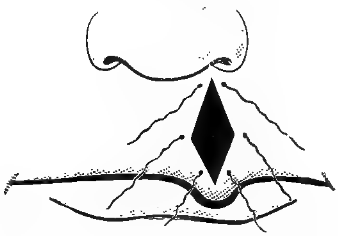
Either silk thread or silkworm gut is to be employed. Catgut is not to be relied upon for this purpose. If the tension has not been entirely relieved, the button variety may be used for the deep sutures. The superficial approximation is best accomplished by the simple interrupted suture. In tying the knots of the sutures care should be taken that these do not rest upon the line of union, in which situation they may produce sloughs or otherwise interfere with rapid healing. Hare-lip pins and the figure-of-8 sutures are no longer employed.

Methods of Operation in Single Hare-lip.—*Nélaton's Operation.*—Fissures of the first and second degree are corrected as follows: The point of a straight bistoury is entered about 8 mm. above the angle and passed through the entire thickness of the lip. It is then carried in a direction parallel to the edges of the cleft and at a sufficient distance from the latter, downward toward, but not quite to, the vermilion border. This is separated on the opposite side. A Λ-shaped incision is thus formed (Fig. 203). By passing a tenaculum through the apex of the

Fig. 203.

Nélaton's operation: the incision.

Fig. 204.



Nélaton's operation: the sutures.

cleft and drawing down upon the loosened flap, the legs of the Λ are inverted and a rhomboid space is formed (Fig. 204), which is closed by suturing edge to edge. The amount of projection in a downward direction at the vermilion border is to be graduated according to the require-

ments of the case. It should be borne in mind that unless an over-correction of the deformity is made the subsequent contraction of the vertically-placed scar will result in an unsightly notch.

Hagedorn's Operation.—A curved incision (Figs. 205, 206) made by transfixion with a sharp-pointed straight bistoury is made to follow the

FIG. 205.

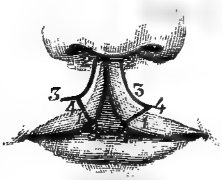
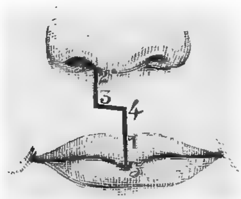


FIG. 206.



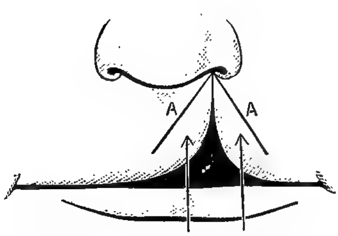
Hagedorn's hare-lip operation.

vermilion border of the lateral side of the cleft, and another incision, shown at 4–3–2, is made on the median margin. The incisions (5–1–4) are made obliquely across the border, and two shorter incisions at 2, also including the border, complete the removal of the whole of the margin from 5 to 2. The points on either side of the fissure marked by corresponding figures are brought together.

Dieffenbach's Operation.—In cases of the third degree this last-named method is not applicable. Here concave freshening of the edges, after Dieffenbach's or some one of the procedures designed to lengthen the edges of the flap, is indicated. Simple concave freshening has now been very generally abandoned in favor of the more rational methods which involve comparatively slight or no loss of tissue.

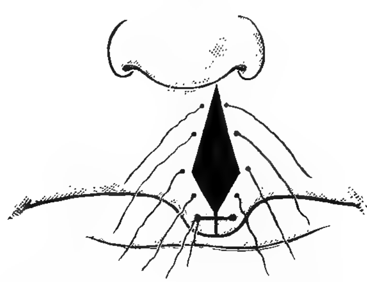
Malgaigne's Operation.—Among the favorite procedures of the present day is that devised by Malgaigne. The incision is begun at the upper limit of the cleft, and is carried downward toward the free border of the lip, but not through the latter. A similar flap is made upon the other side (Fig. 207). Two small flaps, which are adherent to the lip by

FIG. 207.



Malgaigne's operation: the incision.

FIG. 208.

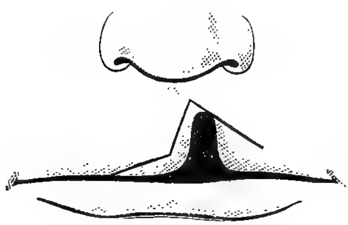


Malgaigne's operation: the sutures in position; the lower sutures tied.

a pedicle, result. These are turned downward (Fig. 208) as in Nélaton's operation, and the resulting space closed by suturing.

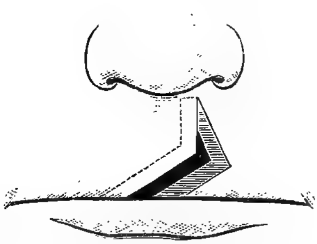
The Mirault-Langenbeck-Dix Operation.—Where the two edges of the flap are not nearly parallel, as sometimes happens, the outer edge having an inclination outward and downward, Malgaigne's operation is inferior to that devised by Mirault and modified by Langenbeck. In Mirault's operation but a single flap is employed. This is taken from above downward, but left attached at the prolabium (Fig. 209). On the other or median side the cleft margin is removed completely. Langenbeck modified this portion of the operation by freshening at an obtuse angle the margin corresponding to the median edge of the cleft. Dix further modified this by sloping the freshened edge so as to remove more of the mucous membrane than of the skin, and treating the flap in a converse manner—*i. e.* by removing more of the skin than of the mucous membrane (Fig. 210). A more

FIG. 209.



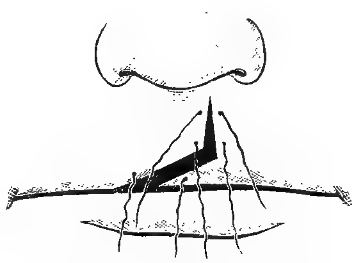
Mirault-Langenbeck operation.

FIG. 210.



Dix's modification of the Mirault-Langenbeck operation: the bevel-shaped flap.

FIG. 211.

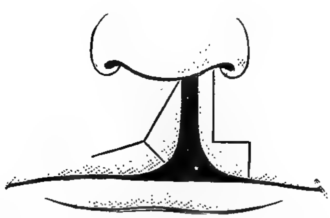


The Mirault-Langenbeck operation: the sutures.

accurate adjustment of the edges is possible by this modification. Fig. 211 shows the method of suturing.

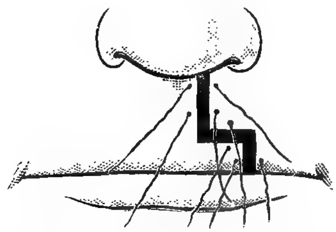
G. Simon's Quadrangular-flap Operation.—The method by quadrangular flap by G. Simon is sometimes employed. In place of the

FIG. 212.



G. Simon's quadrangular-flap operation.

FIG. 213.



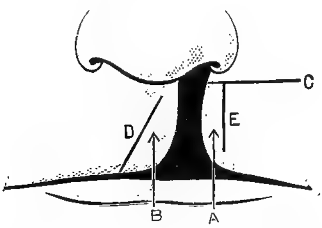
G. Simon's quadrangular-flap operation, showing the adjustment of the parts.

tongue-like flap of Mirault a quadrangular flap, 3 or 4 mm. broad, is made (Fig. 212), and a corresponding freshening of the opposite edge of

the cleft. The ⅃-shaped line, when the flap and freshened edges are brought together and sutured, forms a very complete correction to the deformity (Fig. 213). The upper portion of the cleft where it passes into the nostril is freshened and sutured independently. One advantage which this operation possesses is that the cicatricial contraction is distributed over three separate lines, the minimum amount of shrinkage at the vermilion border occurs, and a lip much more sightly in every way is thus formed.

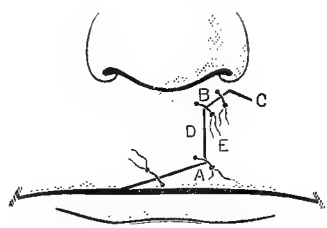
Giraldès' Operation.—Giraldès' procedure is what is known as the "mortise operation." It is described as follows: First, an outer flap (*E*) is formed, attached *below*, as in Mirault's operation (Fig. 214). Second, an inner flap is formed (*D*) by cutting from *below upward;* this flap is left attached near the *upper* limit of the cleft, near the nostril.

FIG. 214.



The incision in Giraldès' operation.

FIG. 215.

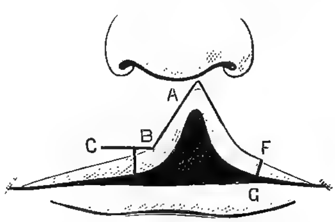


Giraldès' operation: the sutures in position.

Third, a horizontal incision is made (Paré; Guillemeau; Van Horne) to increase the flap, at *C*. The flap *A* is now brought down, the flap *B* is carried up so as to form the edge of the nostril, and the freshened edges thus brought into apposition are sutured (Fig. 215).

Golding-Bird's Operation.—This is known as "the rectangular operation." After freely loosening the parts from the bone the upper angle at one side is transfixed, and the cut carried downward till the lower angle is reached (*A*, *B*, Fig. 216); the knife is now turned and carried horizontally (*B*, *C*) for a short distance. At the middle of this horizontal line a vertical cut extends through the vermilion border. A similar incision is made upon the opposite side (*A*, *F*, *G*), omitting the horizontal cut. Both skin and mucous-membrane sutures are employed. The resulting scar resembles somewhat that following Mirault's or Giraldès' operation.

FIG. 216.



Golding-Bird's operation.

In the selection of an operation the following should be borne in mind: In new-born children and during infancy and early childhood the operation chosen should be the simplest that can be adapted to the exigencies of the case, the object being to avoid as far as possible large losses of blood. Later in life, if the surgeon desires or the vanity of the patient prompts, more complicated procedures may be employed.

It becomes necessary occasionally to equalize the openings in the

nostrils, for the reason that, following the most perfectly devised operation, one naris will be found to be much larger than the other. This is best accomplished by detaching the cartilaginous septum from the floor of the nasal cavity and carrying it toward the wider nostril, having previously freshened a surface at this point for its reception. It is here sutured, and the side from which it was displaced kept plugged with antiseptic gauze for a few days. Operations of this character are best performed after the lapse of several years following the original procedure.

Operations for Double Hare-lip.

Time for Operation.—While single hare-lip may be operated upon comparatively early in life, in double hare-lip it is better to delay the operation until the second year of life if the nutrition of the child can be maintained in spite of the deformity. As before stated, failure in this respect may necessitate an earlier operation.

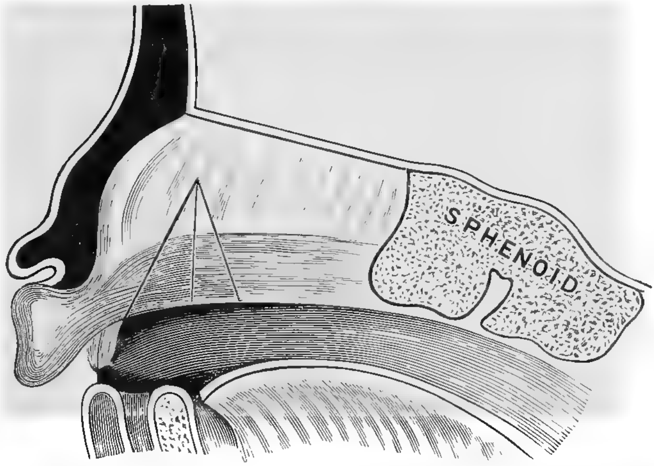
Disposition of the Intermaxillary Bone.—In operations for double hare-lip an important question for discussion relates to the disposition to be made of the intermaxillary bone. In cases of but slight elevation or of entire absence of the projection the labial clefts may be closed at once. Usually, however, the intermaxillary bone will be found to be a serious obstacle in the way of a restitution of the parts. If the case is sufficiently favorable to permit of closure of the labial cleft at once, this exercises a favorable influence over both the cleft and the prominent bone. The latter gradually recedes to its normal position and unites with the alveolar processes. In a very marked prominence, however, this should not be attempted, for the reason that the displaced bone will exercise such an amount of pressure as to prevent union of the soft parts. Under these circumstances the prominence of the intermaxillary bone must be reduced.

The removal of the intermaxillary bone at the present day must be considered as but little short of an unjustifiable mutilation. Its functional and cosmetic uses are such as to demand its retention. In order to effect its reduction different methods have been devised, such as—(1) forcible fracture and crowding backward of the vomer (Gensoul); (2) excision of a triangular portion of the vomer close behind the intermaxillary bone (Blandin); (3) simple vertical section of the vomer and overlapping of the two sides (Rose); and (4) the method of uniting long flaps of both lips and cheek with the central portion, without regard to the cosmetic effect, and trusting to the pressure of the thus restored margin to reduce the projection. A plastic operation is resorted to afterward in order to improve the shape of the mouth (G. Simon). The method of Gensoul is applicable only after ossification of the vomer has taken place; it will be found impossible to fracture the vomer while in its cartilaginous condition. Simon's method is objectionable because of the length of time occupied and the very unsatisfactory condition of the parts in the interval. Blandin's procedure, or some one of its modifications, is greatly to be preferred.

Blandin's Method of Reducing the Intermaxillary Bone.—Blandin's original procedure, which consisted of the removal of a triangular-shaped

piece of the vomer, together with its covering (Fig. 217), is open to the objection that hemorrhage difficult to control frequently attends its employment. In addition, failure of union between the posterior border of the intermaxillary bone and the vomer occurs. The first disad-

FIG. 217.



Antero-posterior section through intermaxillary bone, vomer, etc.: F. Blandin's operation for the removal of a triangular-shaped portion of the vomer. The dotted line marks the site of the division of the vomer in Rose's operation.

vantage could be overcome by the thermo-cautery, or Bruns' temporary compression loop passed through the vomer behind the point of proposed excision. Failure of union, however, would still constitute a serious objection.

Modifications of Blandin's Procedure.—Almost simultaneously, in 1868, four surgeons, Bardeleben, Guérin, Delorme, and Mirault, suggested essentially the same modification of Blandin's procedure. This consists in making a subperiosteal resection of the vomer. This is done through an incision along the edge of the vomer, lifting the muco-periosteal covering of the bone from the latter by means of a slender elevator, and, holding these out of the way by means of retractors, the triangular portion of the bone is removed by means of a pair of stout scissors. The remainder of the vomer is now forced back to its normal position from in front.

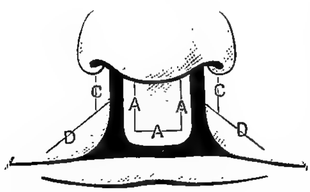
Rose's Procedure.—Rose, in modifying Blandin's operation, after separating the muco-periosteal coverings, as in the last-named procedure, made a simple vertical cut through the entire thickness of the vomer (Fig. 215), and then forced the anterior portion of the bone backward, causing the two portions to overlap each other, the lateral surfaces becoming united.

Either of these modifications will give a very satisfactory result. If care is taken to keep the elevator close to the bone while lifting up the covering of the latter, no vessels of importance are injured and the operation is almost a bloodless one.

Steps of the Operation for Double Hare-lip.—The steps of the opera-

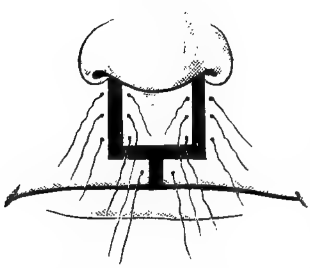
tion for double hare-lip are as follows: (1) The skin overlying the central portion or the intermaxillary bone is pared at its margins so as to leave a quadrangular space with thin wound-surfaces (Fig. 218, *A, A, A*). On no account should the strip of skin upon the intermaxillary bone be removed or displaced upward to lengthen the nasal septum, as was formerly taught. (2) From the outer edge of each cleft is formed a flap similar to that formed in Malgaigne's operation for simple hare-lip, these flaps remaining attached each by a pedicle to its corresponding portion of the lip (Fig. 216, *D, D*). (3) The remainder of the outer edge of each cleft is freshened by removing the margins above the point from which the flaps were taken in an upward direction to the alæ of the nose (Fig. 216, *C, C*). (4) The flaps taken from the outer edges of the clefts are now approximated to the horizontal surface of the tip of the central portion, the thin extremity of each flap being trimmed with the scissors so as to meet in the middle line, where both of the clefts are closed. The tension must be relieved by loosening the lip and cheek from the superior maxillary bone with scissors, as heretofore described. The parts when ready for suturing should appear as in Fig. 219.

FIG. 218.



The operation for double hare-lip.

FIG. 219.



Operation for double hare-lip: the sutures in position.

After-treatment. — *Dressings.* — Ordinary dressings should not be applied after the operation of hare-lip. The restlessness and irritability which they produce more than outweighs the benefit derived. Thorough drying of the edges of the wound and pencilling with collodion mixed with iodide of bismuth constitutes the best dressing. Even this is sometimes omitted with advantage, occasional cleansing being substituted.

Every effort should be made to prevent the child from crying. Feeding should be carried on with a small spoon. The entire attention of the nurse or mother should be directed to this end. The oral cavity should be cleansed by means of bits of absorbent cotton grasped in a forceps or tied upon a stick, and dipped in a solution of boric acid of about the strength of a drachm to the pint. If the bowels do not move within the first twenty-four hours, a suitable purge should be given. One or more dark-colored alvine dejections will usually occur as a result of the blood which has been swallowed.

Removal of the Sutures.—The sutures should be removed on or about the sixth day. The union may be complete or partial. If only the vermilion border has united, the gap left by failure of union of the remainder of the cleft will close by granulation. This may be assisted by approximating the granulating edges with adhesive plaster. Should complete failure of union occur, an attempt may be made to bring the edges together by secondary sutures. Usually, however, the tissues will not bear the strain of these in their softened and inflamed condition; a

second operation after from four to six weeks, following the first operation, should be done by preference.

In cases in which a fatal result follows the operation, death takes place either from hemorrhage, or from broncho-pneumonia.

Cleft-palate.

Palatal defects or fissures are either congenital or acquired. In the former the cleft may only involve the soft parts, or both hard and soft palate may be the site of the defect, in which case hare-lip is usually associated. While fissure of the soft palate may occur without that of the hard palate, defect of the latter is always associated with a split of the velum.

In some cases of cleft-palate neither of the palatine processes reach to the vomer; in others one palatine process passes to the vomer, while that of the other side does not. Finally, one palatine process may be partly attached—*i. e.* anteriorly and posteriorly, with a cleft between. When neither palatine process reaches the vomer, the intermaxillary bone is carried forward by the projecting lower edge of the vomer: this condition is usually associated with double hare-lip. When either of the palatine processes is attached to the vomer, the latter is simply deflected toward the fissured side; here single hare-lip is generally present.

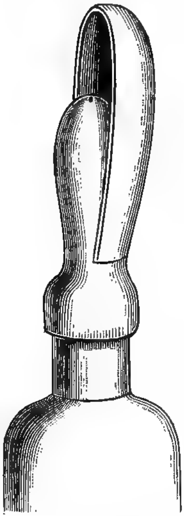
Fissures of the Soft Palate.—Fissures of the soft palate are, almost without exception, placed exactly in the median line. Even the uvula is split exactly in the middle, one half of it and the velum hanging upon either side. The muscular apparatus is normally developed. When the soft palate alone is affected the fissure terminates in an acute angle at the posterior edge of the hard palate, or even invades this for a short distance. There may be all degrees of fissure, from the above to a slight split of the uvula alone (bifid uvula). Defects of the hard palate, on the other hand, are almost necessarily asymmetrically placed.

Acquired Cleft-palate.—The causes of acquired cleft-palate include perforating wounds and constitutional syphilis. Those due to traumatism may vary in form and extent; those due to syphilis, however, present a rather constant and characteristic form. The fissure is of an oval or oblong shape. The syphilitic lesions are mainly confined to the velum pendulum palati, and various degrees of destruction of this structure may be present. The gummatous infiltration is usually at first in the median line, and one or more perforations of the velum may arise. Fusion of several of these may lead to the oval opening above alluded to. Much more frequently, however, the ulceration extends from the posterior surface of the velum to the lateral pharyngeal wall, and subsequent cicatricial contraction drags the margins of the remains of the soft palate to either side, and the site of the former velum is occupied by a triangular-shaped defect, the cicatricial edges of which seem welded to the lateral pharyngeal wall, and enclose a large opening which leads in an upward direction to the nasal fossa, and downward to the rima glottidis.

Functional Disturbances.—*Deglutition.*—The functions of deglutition and speech are essentially interfered with in cleft-palate. In the first named the food is crowded into the nasal fossa by the action of the

tongue in attempting to force it into the pharynx. The latter organ becomes in some instances unduly developed in the constant attempts to perform this portion of the process of deglutition properly. The muscular structures of the palatine region in fissures of the velum are also developed beyond the normal. This is particularly true of the muscular fibres upon the posterior pharyngeal wall, which by their action seem to resist the tendency of the food to pass upward to the nasal cavity upon contraction of the lower pharyngeal constrictors. In spite of this, however, small particles of food pass into the nasal cavity in children, and produce not only considerable inconvenience, but some dangers from decomposition and consequent inflammatory conditions. This is particularly true of curdled milk, which in infants still upon the bottle may pass into the recesses of the turbinated bones and give rise to aphthous patches here. A nipple with a shield-shaped device may be advantageously employed to prevent this (Fig. 220).

FIG. 220.



Nipple and shield (Mason).

Interference with Speech.—The principal interference with the function of speech relates to the enunciation of vowel sounds. This arises from the failure to properly shut off the nasal cavity from that of the mouth. The extent of this interference with speech will depend (1) upon the size of the cleft, and (2) upon the greater or less ability on the part of the patient to shorten this by muscular effort. The interference with speech may thus reach all grades, from a slight nasal intonation to an absolute unintelligibility. Acquired cleft is not so apt to give rise to the extreme degrees of interference. This is particularly true of syphilitic destruction of the soft palate, the cicatricial contraction so narrowing the naso-pharyngeal communication that but slight effort is required on the part of the surrounding muscular structures to complete the closure.

In cases in which large palate defects exist, the formation of such sounds as depend upon the approximation of the tongue to the roof of the mouth is interfered with. In fact, between imperfect formation of the last named, as well as such explosive sounds as *b* and *p*, which require a preliminary filling of the oral cavity with air, and inability to pronounce the vowels and many of the consonants, attempts at vocalization are sometimes absolutely futile, as well as exceedingly painful to witness.

Treatment by Obturators, etc.—Patients will sometimes instinctively attempt to fill the defect with foreign bodies, portions of food, etc. Obturators of various kinds have been devised by the dentists. These are fastened to the teeth, and for this reason their employment must necessarily be postponed until the teeth have appeared. By this time a habit of speech will have been formed which only careful and painstaking training can overcome. Kingsley of New York has introduced to the profession an artificial palate and velum, the aim of which is to replace, as far as possible, the natural form of the defective parts with such material as shall restore, to some extent, their function. For this purpose

the velum portion of the obturator is made of soft vulcanized rubber, and this soft elastic substance, filling the gap in the soft palate with a flap behind as well as in front, enables it to follow the movements of the muscular apparatus upon either side with which it comes in intimate contact.

Süerson's method of correcting the deformity by apparatus is as follows: A horizontal plate is placed in the pharyngeal cavity, separating the upper portion of the latter, or naso-pharyngeal space, from the lower. A bridge connects this with the portion of the apparatus which covers in the defect of the hard palate, which portion is attached to two of the teeth. This bridge is received into the fissure of the soft palate. In order to provide for nasal respiration, and at the same time permit of such sounds as require vibration of the air contained in the nasal cavity, the plate for the pharyngeal portion of the apparatus is made after a wax model, which in its turn is moulded into shape in the patient's pharynx and while he is enunciating the sounds above alluded to. The contracting muscular structures produce certain impressions in the wax, and with this as a model these are reproduced in the gutta-percha pharyngeal plate. While the parts are at rest a space is left for nasal breathing, but when the muscles are brought into play for the production of sounds the nasal cavity is closed and the nasal sound of the vowels prevented. The same principle may be applied in the correction of acquired cleft-palate.

Operative Treatment of Cleft-palate.—The operative procedures instituted for the cure of cleft-palate are called, in the case of the soft palate, *staphylorrhaphy*, and in the case of the hard palate, *uranoplasty*. In 1816, Roux and Gräfe almost simultaneously attempted the operation of staphylorrhaphy, and Dieffenbach later introduced the lateral incisions through the velum for the purpose of relieving the tension. Division of the levator palati muscles for the latter purpose, suggested by Fergusson, was found to be still more effective.

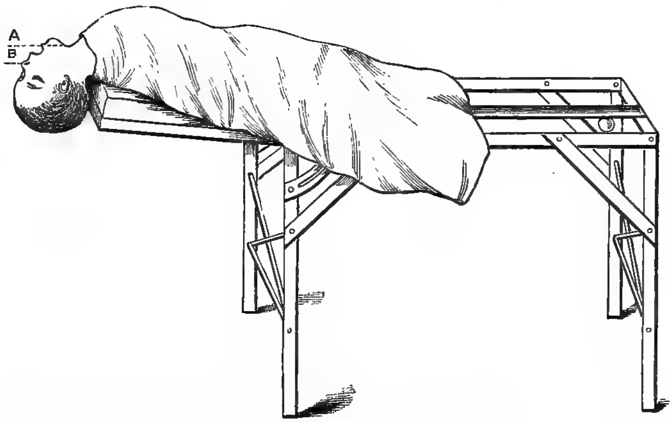
Time for Operation in Cleft-palate.—The mortality from cleft-palate operations in early infancy, say before the fourth month, amounts to almost 50 per cent. (Ehrmann). The most favorable time for operation is at the fifth year (Schede), although Ehrmann concludes, upon the basis of an experience in fifty cases, that uranoplasty usually interferes with the development of the skeleton of the arch, and for this reason he believes that operations should be postponed to the period of the second dentition (the tenth or twelfth year).

The frequent failure to procure a good functional result when operations were done after the child commenced to talk was attributed to the late operation and the necessity for extensive myotomy and its consequent crippling effect (Wolff). No better functional results, however, follow early operations. Sloughing of the muco-periosteal flaps in very young infants also constitutes a risk to which particular attention has not hitherto been drawn.

The Employment of Anæsthetics in Staphylorrhaphy and Uranoplasty.—Rose's dependent head position is to be employed in cleft-palate operations. The patient's head is placed at the edge of the table, and a hard roller or cushion placed beneath the neck in such a manner as to elevate the chin and depress the occiput, the head hanging over the edge of the

cushion. The larynx is above the level of the oral and the nasal cavities, and the blood cannot pass into the air-passages, but flows out of the nose and mouth (Fig. 221). Prior to its introduction it was deemed an

Fig. 221.

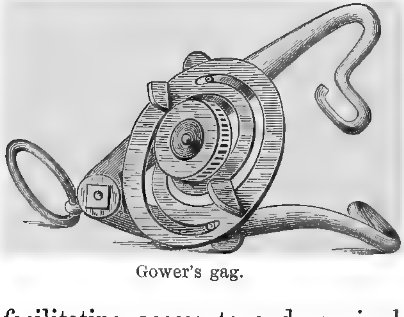


Rose's dependent head position: *A*, level of glottis opening; *B*, level of nasal opening—to show escape of blood from nose during operation.

exceedingly dangerous procedure to undertake the operation under an anæsthetic, on account of the amount of blood which would almost inevitably find its way into the air-passages. Since the introduction of cocaine anæsthesia this agent is employed in a solution of from 10 to 20 per cent. Although this will assist materially in lessening the pain, the deeper parts will remain sensitive in spite of its use. It should be very sparingly employed in young children.

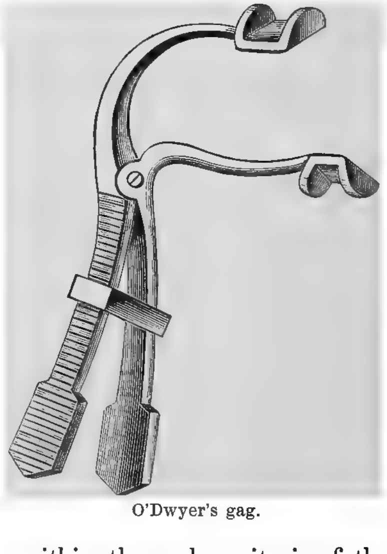
Mouth-gags for Operations upon Cleft-palate.—The employment of suitable mouth specula or gags for facilitating access to and manipulation within the oral cavity is of the greatest importance. Of these there are employed Gower's (Fig. 222), O'Dwyer's (Fig. 223), French's (Fig. 224), and Whitehead's (Fig. 225).

Fig. 222.



Gower's gag.

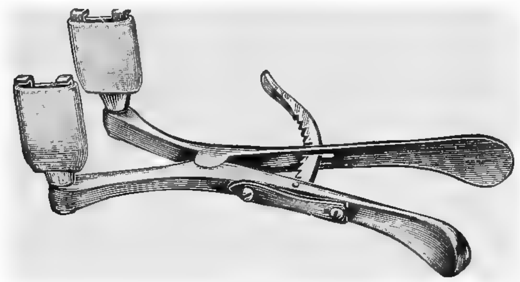
Fig. 223.



O'Dwyer's gag.

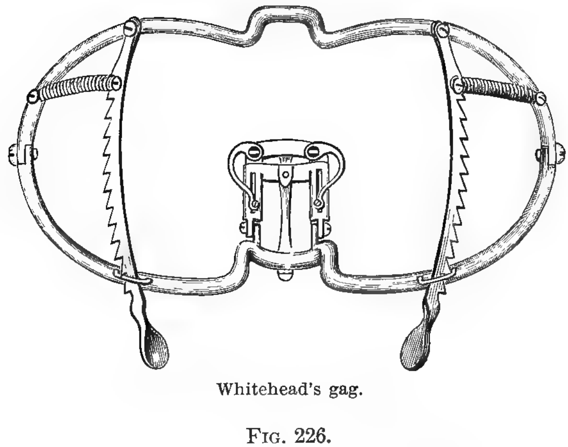
The last-named has a tongue-depressor attachment. When the others are used it will be necessary to pass a thread through the tongue in order to hold this organ out of the way. The first-named affords the largest working space, which may be very materially increased by the cheek-retractor (Fig. 226).

FIG. 224.



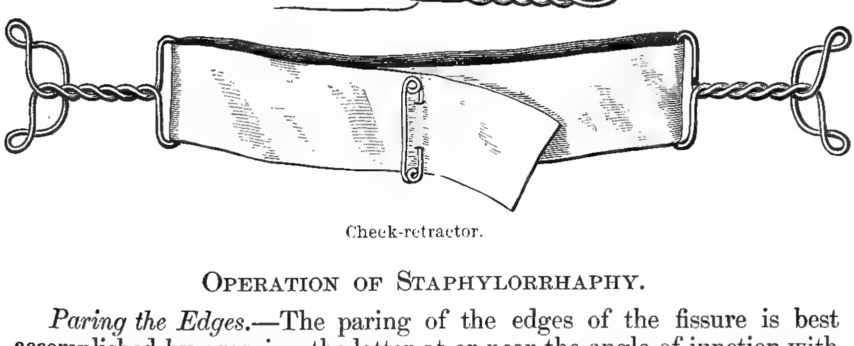
French's gag.

FIG. 225.



Whitehead's gag.

FIG. 226.



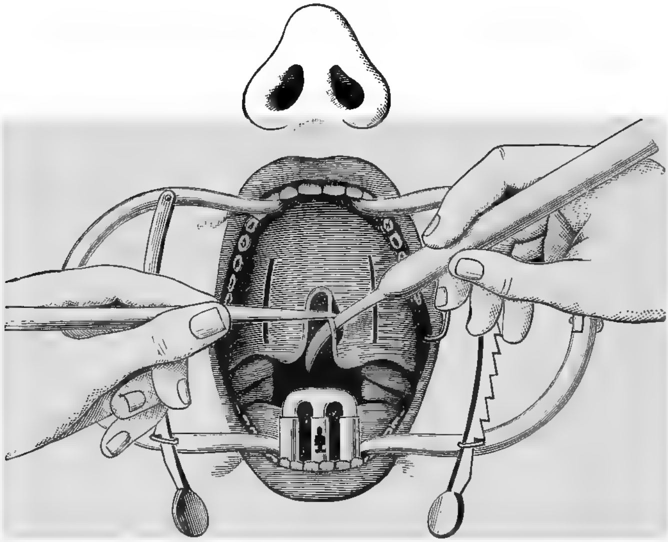
Cheek-retractor.

OPERATION OF STAPHYLORRHAPHY.

Paring the Edges.—The paring of the edges of the fissure is best accomplished by grasping the latter at or near the angle of junction with the hard palate by means of a tenaculum or mouse-toothed forceps, pass-

ing a narrow and thin-bladed bistoury through one edge just in front of the angle, and by gentle to-and-fro movements cutting directly backward until the termination of the cleft is reached at the tip of the split uvula (Fig. 227). The same manœuvre is repeated upon the other side. By

FIG. 227.



The operation of staphylorrhaphy ; paring the edges.

a sweeping movement a curved cut unites these together at the bottom of the angle, and the paring is removed in one piece, which is absolutely essential in order to be certain that the entire surface of both edges is denuded.

Division of the Muscles.—This may be done either before or after the introduction of the sutures. If before, Langenbeck's sickle-shaped knife or Fergusson's myotomy knife may be employed. This is passed through the cleft, and its point introduced over the hamular process of the internal pterygoid plate of the sphenoid bone, which can be easily felt by the finger pressed upon the soft palate in close relation to the last upper molar. The corresponding portion of the velum is made tense while the section is made. If done after the suturing, a narrow-bladed knife is introduced through the soft parts halfway between the hamular process and the Eustachian tube, and an oblique incision made outwardly. The levatores palati are thus divided. The tensores palati are not believed to greatly influence the edges. If deemed necessary, they may be divided by introducing a narrow knife, with the edge upward, just along the inner side of each hamular process, and cutting upward a few lines. If the tension is not completely relieved by the division of the above, the palato-pharyngei should be divided by simply cutting across the posterior pillars, just below the tonsils, with blunt-pointed scissors (Fergusson).

Introduction of the Sutures.—An ordinary half-circle Hagedorn needle

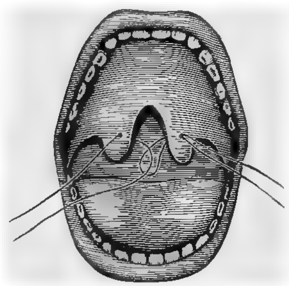
grasped by a needle-holder, when it can be employed, serves best for the introduction of the sutures. When but a narrow working space is available, the Reverdin needle (Fig. 228) answers better. This is passed from

Fig. 228.

Reverdin's needle.

one side *armed*, and the free end of the thread, passed through only one side, left loose and the needle withdrawn. The needle is now introduced *unarmed* from the other side, and the eye of the needle being opened by withdrawing the slide, the loose end of the thread is placed therein, the eye closed, and the needle withdrawn along with the thread, thus completing the suture. Or a needle with the eye at the point and set in a handle may be used in the same manner, a double thread forming a loop being introduced at the second stage, and this employed to withdraw the thus completed suture (Fig. 229). A good quality of Chinese twist is the best suture material.

Fig. 229.



Passing the sutures.

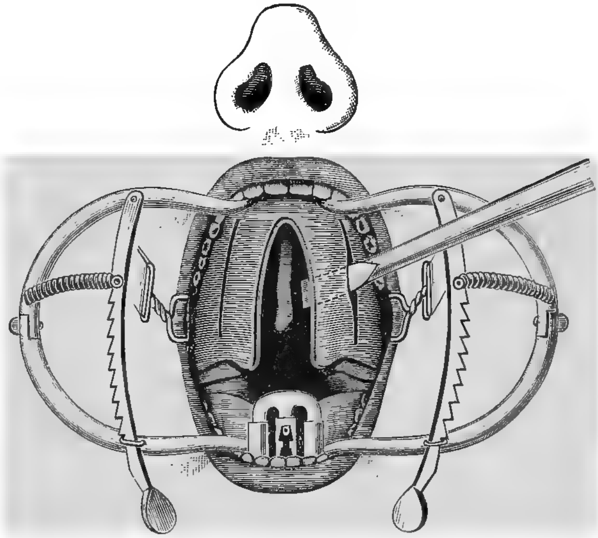
Uranoplasty.—Special difficulties, in addition to those met with in staphylorraphy, present themselves in closing clefts of the hard palate. Many failures followed these attempts until Langenbeck in 1860 developed the method known as the lateral muco-periosteal flap.

Langenbeck's Operation.—This operation consists essentially in loosening the muco-periosteal covering of the palatal processes of the superior maxillary bone in the shape of lateral flaps, which are united in the median line to cover the defect. The advantages claimed for this procedure are—(1) the mucous membrane and periosteum are much more easily detached together than the former separately; (2) the trunk as well as the branches of the palatine artery are protected from injury because of their location between the periosteum and mucous membrane, thus vitality to the flap is ensured; (3) the material employed for the correction of the defect is much more effective and stable than simple mucous membrane, even if new bone does not develop from the periosteum, as has been claimed.

Inasmuch as staphylorrhaphy and uranoplasty are usually combined in cases of cleft of both the hard and soft palate, the paring of the edges described in connection with staphylorrhaphy is to be extended to include that of the hard palate as well. Two lateral incisions (Fig. 230), extending down to the bone, are now made, one at the margin of each alveolar border, by means of a blade shaped like a gum-lance. It is important that these incisions do not approach the median any nearer than absolutely necessary, particularly at the posterior part, for the reason that at this point the palatine artery passes through the palatine foramen to the mucous membrane, and cannot easily contract within its

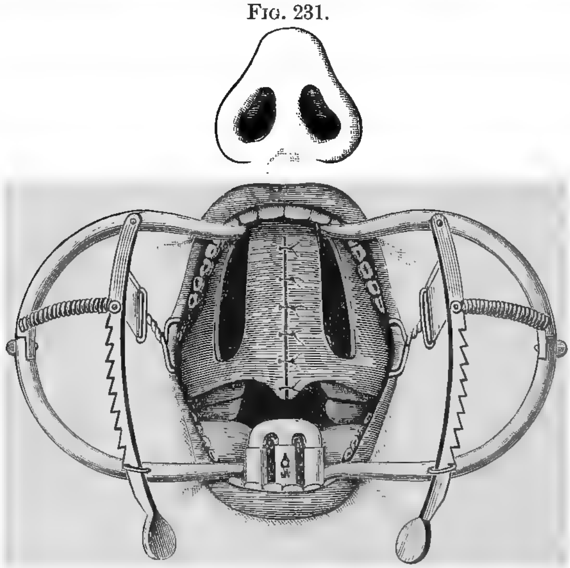
bony channel if injured. The chisel-shaped curved elevator is now introduced to the bottom of the lateral incisions, and the periosteum and mucous membrane lifted together from the bone beneath. When this is

Fig. 230.



Detaching the muco-periosteal flap.

Fig. 231.



Line of approximation after staphylorrhaphy and uranoplasty.

completed the edge of the elevator will appear in the cleft (Fig. 231). Careful separation of the flap in all directions is thus secured.

In syphilitic cases some difficulty may be experienced in separating

the coverings from the bone. The knife may be here applied. In congenital cases, however, these lift away readily.

The hemorrhage is usually arrested promptly by means of pressure; the use of tampons soaked in ice-water is sometimes useful. If very persistent, tampons may be packed behind the palate, after suturing, with threads for withdrawal, as in plugging the posterior nares in epistaxis.

The sutures are applied as in staphylorrhaphy. Care should be taken that the knots, when the threads are tied, lie to one or the other side of the line of union.

URANO-STAPHYLORRHAPHY WITHOUT DIVISION OF THE MUSCLES.—Here the tension incisions are dispensed with. The medial plate of the pterygoid process is separated submucously, on a level with the base of the hamular process, so that by a dislocation at the point of insertion the palatine tension is temporarily relaxed (Billroth). Or incisions may be made in the usual manner in the hard palate, and the muco-periosteal structures, as in the latter, carefully loosened in all directions, and the edges of the cleft approximated and sutured. Section of the muscles being entirely omitted, there is less risk of interference with speech from this cause (Julius Wolff).

Urano-staphylorrhaphy in Two Sittings.—It has been deemed an advantage, under some circumstances, to perform this operation in two sittings. An interval of from twenty-four to forty-eight hours is allowed to elapse between the two stages. At the first sitting the usual lateral incisions are made on both sides, and the muco-periosteal flaps loosened from the bone; the hemorrhage is arrested by forcipressure and subsequent compression. At the second sitting the edges are pared and the sutures introduced. Two objects are to be gained by this procedure: (1) the first stage, in which considerable blood is necessarily lost, is not prolonged to the extent of producing an undue amount of shock, and the bleeding from the posterior palatine arteries is most readily arrested by the pressure of the overlying although loosened flaps (Polaillon); (2) the nutrition of the flaps is more certainly secured in this method of operating (Julius Wolff).

Modifications.—In partial fissure—*i. e.* where but one nasal cavity is opened, the defect being confined to but one palatal process—a muco-periosteal flap is taken from the nasal portion looking toward the fissure, turned down, and sutured to the freshened edge of the fissure (Lannelongue). In traumatic or syphilitic defects a flap from the entire thickness of the cheek may be carried in at the site of an extracted upper molar (Thiersch). Suturing both halves of the velum to the posterior pharyngeal wall (Passavant), and filling the triangular-shaped gap in the soft palate by a properly-shaped flap taken from the posterior wall of the pharynx (Trendelenburg-Schoenborn), the so-called staphyloplastic procedures, viewed from the standpoint of functional perfection of result, are worthy of further study, particularly where cicatricial contraction (syphilitic) exists.

Davies-Colley Operation.—A method of closing the cleft in cases in which the soft parts have sloughed from previous attempts, and there exists too little tissue to close the palate in the ordinary way, consists of dissecting a triangular-shaped flap, with its base directed posteriorly, from one side of the cleft. A half-elliptical-shaped flap is dissected

from the opposite side; this is left attached to the margin of the cleft. This second flap is now turned inward upon the hinge by means of which it remains attached to the bony edge of the cleft, its oral surface being directed toward the nasal cavity, while its raw surface presents toward the cavity of the mouth. The triangular-shaped or first flap is now displaced, so that its raw surface approximates the raw surface of the second flap, and thus completes the closure of the defect. The flaps are secured to each other by silver-wire sutures, which are allowed to remain in position for from five to six weeks. In very young children the soft palate is closed at a second operation; in those over twelve the whole gap may be closed in one sitting.[1]

After-treatment.—Frequent rinsing of the mouth with a solution of boric acid, potassium permanganate, or weak carbolic solution is indicated. The patient must be prevented, as far as possible, from attempting to cough or expectorate. Nothing but liquid food is to be taken, and the act of swallowing performed carefully. The lateral incisions soon fill up by granulation, and the flaps reattach themselves to the bone. The sutures are removed on or about the seventh day. In cases of failure of union several months must elapse before the operation can be repeated.

Frequent failure to realize the anticipated improvement in the voice follows the operation. It should be borne in mind that a congenital cleft in the palate is not merely a slit in the parts, but an actual deficiency of tissue exists. Hence, even after a most skilfully-performed operation for closure of the cleft, the velum still remains as a tight curtain stretched across between the oral and pharyngeal cavities and the posterior nares, which is too short to reach the posterior pharyngeal wall, and past which the air rushes from the pharynx through the posterior nares, and the peculiar nasal twang is still present. In order to obviate this, certain vocal exercises are not without value, but a perfect production of normal voice and speech by uranoplasty and staphylorrhaphy has probably never been secured. It sometimes occurs that a hypertrophy of certain of the bundles of fibres of the pharyngeal constrictors takes place, and these aid, although but inefficiently, in secluding the nasal cavity.

In order to improve the voice several suggestions have been made, both as to prothetis and operation. In 1879, Julius Wolff directed the after-treatment of a case of operated cleft-palate, the dentist Schitzky performing the mechanical portion. A palatal plate of hard rubber is adjusted, and to this is attached, by a thin pedicle, a small vulcanized-rubber balloon which is loosely inflated with air. The latter is placed in such a position that the strong movement of the velum, as it is drawn upward by the levators, presses against the balloon and forces the contained air backward and laterally, so as to inflate the corresponding portions thereof, completely shutting off the naso-pharyngeal space. This device gives an almost perfectly functional result.

Francis Mason in 1869, in order to improve the voice-sounds following urano-staphylorrhaphy, made two long incisions, extending from

[1] Mr. Davies-Colley has recently described a modification and extension of this operation. The operation has not been simplified nor made more efficient (*British Medical Journal*, April 28, 1894).

the site of each hamular process directly downward and backward, and thus released the velum laterally and converted it into a huge uvula. The operation is to be performed about a month after the closure of the cleft. This procedure enables the palate to be drawn upward and backward, partial closure, at least, of the post-nasal region and improvement of speech following. The patient should be encouraged to use the voice as much as possible after the operation.

Passavant's procedure, and also that known as the Trendelenburg-Schoenborn operation, as before stated, are worthy of further trial in syphilitic cases, but in congenital cleft-palate, although based on correct physiologic principles, they are difficult of execution and unreliable as to their immediate results.

While it cannot be denied that the employment of the apparatus of Kingsley, Süersen, and others gives the best functional results as compared with those following the most successful operations, it is still true that certain cleft-palate cases should be operated upon. This is based upon the discomforts and inconveniences incident to the passage of food into the nasal cavity in some cases, and the ulcerative conditions which are more or less a marked feature of attempts to constantly wear an obturator. Closure of the palatine fissure, and the subsequent performance of Mason's operation or the use of the Wolff-Schitsky obturator, gives the best results attainable by operative means in the present state of our knowledge.

Acquired Palatal Apertures.—Aside from the comparatively rare cases in which openings in the palate result from accidental or self-inflicted gunshot wounds of the roof of the mouth, these are, as a rule, attributed to the action of the syphilitic virus. While it is unquestionably true that syphilis may, and frequently does, produce necrosis in this region, and consequent loss of substance, yet cases come under the observation of the surgeon very frequently in which no history of the primary lesion can be obtained (Mason; Sir James Paget). Measles has been known to result in necrosis of the hard palate and consequent perforation; and ulcerations of the palate, complicated by exfoliation of bone, occur in ill-nourished, pale, and cachectic people. Even though these patients improve under increasingly larger doses of iodide of potassium, increasing in appetite, weight, and strength to a most surprising extent, yet other evidences that the disease is due to a syphilitic taint are utterly and entirely lacking.

The results obtained in operative attacks upon acquired apertures in the hard palate give very little encouragement: failure is the rule and success the exception. It occasionally happens that after three or four attempts a cure is effected. As before stated, cicatricial contraction when the soft palate breaks down affords a fair substitution for the original velum, for the voice is not as much impaired by an opening in the velum as in the case of the hard palate. Passavant's or the Trendelenburg-Schoenborn operation may be tried if, the active disease being arrested, the cicatricial contraction is not sufficient to overcome the impairment of speech.

Apertures in the hard palate resulting from disease or injury are best treated by means of apparatus. These, however, should be fitted with great care, for ulceration is apt to occur: it is this constant tendency to ulceration, in fact, which so frequently induces patients to demand, and

surgeons to attempt, the closure of these perforations by operation. The practice followed by some patients of filling these openings with material softened and chewed for the purpose (chewing-gum, papier maché, etc.) should be discouraged, as tending to enlarge the openings. The dentist's art should here be brought into play.

Rhinoplasty.

Such destructive processes as lupus, carcinoma, and syphilis require plastic procedures to repair the damage caused by their ravages. Traumatic defects likewise occasionally demand their performance.

Rhinoplasty may be divided into complete and incomplete. It is also divided according to the location of the part from which the material for repair is taken. When taken from the forehead, it is known as the Indian or Hindoo operation; when the skin of the arm is used, it is called the Italian or Tagliacotian operation;[1] when flaps are taken from the skin of the face, it is called the French method. Various modifications and combinations of these are likewise employed to fulfil special indications in individual cases.

Fig. 232.

1, space from which the flap from the root of the nose is taken; 2, flap from root of nose turned down; 3,3, flap from the forehead, forming new nose, sutured in position over 1 and 2; 4, space left after suturing defect in the forehead; 5,5,5,5,5, dotted lines showing lines of incision in forming the forehead flap.

The Indian Method.—The operation of rhinoplasty became widespread in its application in India from the fact that cutting off the nose was employed as a common punishment for crime. A low class of native priests, the Brahmins, usually undertook the task of repairing the mutilation.

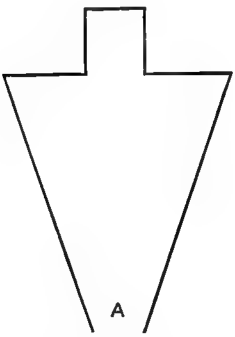
Total Rhinoplasty after the Indian Method.—While the total loss of all of the structure of the nose is very uncommon, severe lupous ulceration may require the restoration of the tip of the nose, both alæ, and the septum, and for practical purposes this may be considered as total rhinoplasty. The first stage of the operation consists in freshening and broadening, as much as possible, the cicatricial edges of the defect, and making a transverse incision at the point where the new septum is to be implanted. In order to increase the thickness of the tissues of the anterior portion of the newly-formed nose, Bardeleben, Volkmann, and Hueter modified the original procedure by turning down a flap from the skin covering the root of the nose. A horseshoe-shaped incision (Fig. 232) is made with its convexity directed upward, the aim being to utilize as much as possible the integument at the root of the nose. The flap thus

[1] So named from Tagliacozza of Bologna, who is generally given the credit of having introduced the method. Alexander Benedictus of Padua, however, wrote upon the subject in 1495, and Branca, a Sicilian, became famous because of the successful performance of the operation prior to Tagliacozza's writings. For a long time the profession was incredulous concerning this operation, and as late as 1742 the Faculty of Medicine of Paris decided that such replacement of the lost or destroyed nose was an impossibility.

marked out is dissected loose from the nasal bones and periosteum, and left attached near the margin of the defect. Even if considerable cicatricial tissue is present, it may be used advantageously. The flap is now turned down (Fig. 232), its raw surface looking forward while the skin surface faces the nasal cavity. This portion of the procedure furnishes a greater thickness of flap where it is most required, and offers a firm foundation and broader wound-surface for the reception of the frontal flap.

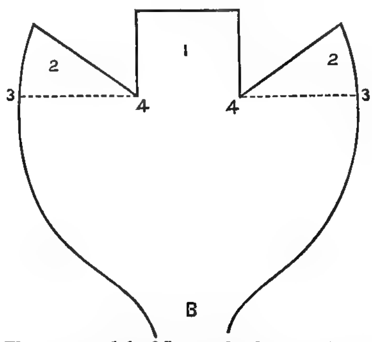
The second stage of the operation consists of the formation of a flap, which is properly fashioned from the skin of the forehead. The lines of incision to accomplish this vary. The fact should be borne in mind that proper nourishment must be provided for the flap, and in order to accomplish this most satisfactorily it is recommended that the angular artery, which is the direct termination of the trunk of the facial, be included in the pedicle and flap. A model of pasteboard or leather may be prepared beforehand, and shaped, after being cut out to follow the lines of incision of Dieffenbach (Fig. 233), Langenbeck (Fig. 234), or König (Fig. 235), to

FIG. 233.



The older model of Dieffenbach.

FIG. 234.



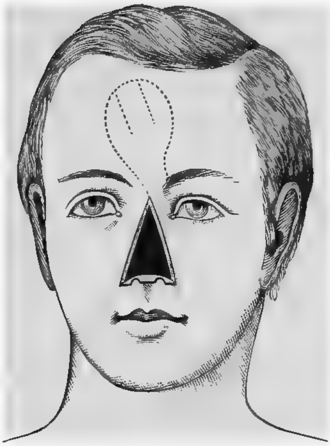
The new model of Langenbeck: 1, septum; 2,2, portions to be doubled back to increase the thickness of the nostril; 3,4,3,4, dotted lines at the points where folding back of the flap occurs to form double edge of nostrils.

about the required size. Ample allowance must be made for shrinkage of the flap: this is of more importance than aiming at as slight a defect as possible in the frontal region. The latter can be closed by making, if necessary, incisions to relieve tension in the temporal region, where the hair will cover the scars. The lines of Langenbeck (Fig. 234) are to be preferred for the reason that the portion at 2 can be folded in on the line 3–4, so as to form a double edge to the new nostril. The septum should be made more than double the width finally required, to allow both for shrinkage and doubling back or hemming of its edge (Delpech). Septum and nostrils, by means of this device, are covered for some little distance, both on the intra-nasal surface and externally, with integumentary tissue (Fig. 236).

The frontal flap must be dissected up from the periosteum. The edge of the knife should be directed toward the pericranial surface in order to avoid injury to the vessels supplying the flap. The pedicle must be made sufficiently long to avoid undue pressure upon the vessels when the former is twisted upon itself, as the flap is brought down into position with its raw surface looking posteriorly. As an additional pre-

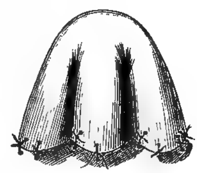
caution, and to facilitate the necessary reversing of the flap surfaces, the incision marking the margin of the pedicle should be longer upon one side than upon the other. The portion intended for the formation of a septum may reach to the margin of the hairy scalp. The forehead defect is at once remedied by approximating its margins as much as possible; this likewise seems to arrest the hemorrhage (Fig. 232). The gap left at 4 may be immediately remedied by a skin-transplantation strip after the method of Thiersch.

Fig. 235.



Lines of incision in König's rhinoplastic operation.

Fig. 236.



The appearances presented by the doubled-back margins of the flap to form the septum and nostrils, as seen from below.

The alæ and septum are now folded so as to appear as shown in Fig. 236, and secured by means of catgut sutures. The latter should not penetrate the skin, but simply take in the subcutaneous cellular tissue. The flap is now adjusted to its proper position, and there secured by fine silk sutures. The septum is fastened to the upper lip, at the incision made to receive it, by two or three sutures.

Preliminary Transplantation of a Finger-tip.—As a means of preventing the depression of the tip of the nose, Hardie of Manchester and Sabine of New York transplanted, as a preliminary operation, the last phalanx of the left index finger to serve as an osseous basis of support to the cutaneous coverings. The method is as follows: (1) Freshen the edges of the nasal opening. (2) Remove the nail and matrix of the finger; make an incision upon its palmar surface as far back as the inter-phalangeal articulation through the integument; dissect up the latter and suture it to the nasal edges. The arm, hand, and head are fastened immovably in a plaster-of-Paris dressing, antiseptic gauze serving as a dressing to the finger-end in its new position. At the end of four weeks the finger is amputated, and several weeks thereafter the usual rhinoplastic operation is performed.

Thiersch endeavored to accomplish the same end by placing the flaps, one taken from each cheek, in a position to replace the septum. Wood recommends transplanting a portion of the upper lip for this purpose. König's procedure consists in making an osteoplastic resection of the outer table of the skull, which is left connected to the soft parts of the frontal flap, and bringing this down together with the latter. The bony portion of the flap is sawn through longitudinally, in order to adapt it to the shape of the nose. By this method the bony surface is exposed in the nasal cavity, and necrosis may result. If the flap is brought down, however, in such a manner as to turn the skin surface toward the nasal cavity and the bony surface outward, and the latter is covered by flaps taken from the cheeks (Thiersch's transplantation strips), a better final result may be secured.

Keegan's Operation.—Surgeon-major Keegan of the British East Indian service has communicated the following method, perfected after an experience in upward of forty cases.[1] It is only applicable to those cases, common in the East, in which the tip and alæ of the nose are cut off, either by highway robbers as a mutilation of their victims or as an official act of punishment.

Two converging incisions (*C A*, *H F*, Figs. 237, 238) are carried from two points slightly external to the roots of the alæ nasi upward to two points about two centimetres apart on the bridge of the nose at the point where a pair of spectacles would rest. A horizontal incision

Fig. 237.

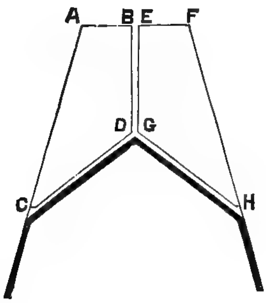
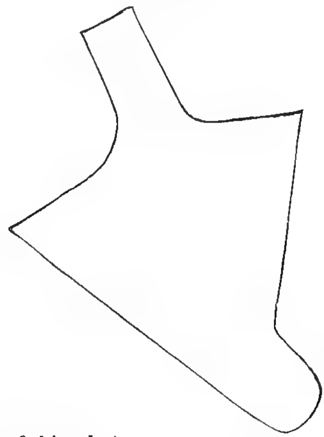


Fig. 238.



Keegan's operation of rhinoplasty.

(*A F*) is now made to join these two points, and this in its turn is bisected by a perpendicular incision (*B D*, *E G*) which follows the junction of the two nasal bones in the median line and stops a little short of their inferior borders.

The skin and tissues are now to be cautiously dissected from off the nasal bones, beginning from above downward, in two flaps (*A B C D* and *E F G H*), which are left attached at the lines *C D* and *G H*, which represent the points of junction of the inferior borders of the nasal bones with the cartilage of the nose. As the two flaps are turned downward their raw surfaces present anteriorly, and their articular surfaces look backward or toward the nasal cavities, the edges corresponding to the median line somewhat overlapping each other. This redundancy of tissue plays an important rôle in the subsequent steps of the operation.

A flap is now taken from the forehead in the usual manner. Dr. Keegan has found, as the result of a large number of experiments, that the flap shown in Fig. 238 is best adapted, both as to size and shape, for the vast majority of cases in adults. The root of the pedicle occupies the internal angle of the eye; the pericranium is not disturbed. The gap from which the forehead flap is taken is closed, before proceeding further with the operation, by fine sutures, in order to procure as accu-

[1] *Lancet*, Feb. 21, 1891, p. 420. The operation of Keegan is here given in detail, for the reason that it combines the best features of the various modifications of the Indian operation that have been suggested.

rate an approximation of its edges as possible. This expeditious closing of the forehead defect reduces to a minimum the amount of raw surface to be filled in subsequently by granulation.

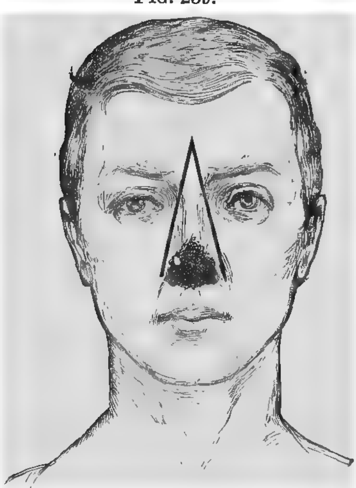
A bed is now prepared for the reception of that portion of the forehead flap which is to form the columna of the new nose. The flaps *A B C D* and *E F G H* raised from the nasal bones are reflected downward, and two triangular-shaped pieces are cut away from the redundant portions at the median line and transplanted to the raw surface left after suturing the gap in the forehead, to hasten the healing process here.

The forehead flap is now placed in position over the nasal bones, its raw surface corresponding to the surfaces of the already reflected flaps taken from the nasal bones, as well as the surface of the latter. The free margins of the forehead flap and those of the nasal flap are fixed to each other by means of sutures. The columna is formed by fixing the portion marked *A* in the bed already freshened to receive it by sutures.

Some fashioning and trimming will now be necessary. The two original incisions (*C A*, *H F*) are to be deepened and bevelled, and into these are to be secured by sutures the lateral margins of the forehead flap. Short drainage-tubes are placed in the newly-formed nostrils, which are lined inside with the skin-covering of the reflected nasal flap. Lint and boracic-ointment dressings are applied. The drainage-tubes are removed in ten days, and the pedicle of the new nose is divided at the end of a fortnight.

Ollier's Operation.—This operation is intended to supply the loss of the alæ, columna, cartilages, and a portion of the septum. The disease (lupus) in the case for which the operation was originally designed had extended to the integument of the lip and cheeks, and these could not be utilized in the formation of flaps. Two diverging incisions, commencing in the median line of the forehead two inches above the eyebrows, were carried downward to within one-fourth of an inch from the outer side of the nasal orifice (Fig. 239). The triangular flap thus formed included at its upper portion the periosteum to the root of the nose. The dissection was carried along the right nasal bone, and did not include the periosteum, but the remains of the cartilage at the latter point were detached and remained attached to the flap. An osteoplastic resection of the left nasal bone was now done, the bone being separated by means of a chisel and left attached to the left half of the flap. The cartilaginous septum was then divided from before backward and downward with scissors, and left attached by its base to the cutaneous cartilage to form a central support for the new structure. The entire flap, including the periosteum from the forehead over the frontal sinuses, the resected left nasal bone, the divided cartilaginous

Fig. 239.



Ollier's method of rhinoplasty.

septum, and the soft structures overlying all these parts, was now drawn downward until the upper border of the loosened left nasal bone came opposite the lower border of the right one, where it was secured by a wire suture. The sides of the flap were then united to the cheek, and the gap in the frontal region closed by sutures. The space left by the removal of the left nasal bone is said to have been filled in, in Ollier's case, by bone developed from the periosteum that had been slid down from the forehead.

Wood's Operation.—The new nose is formed from a broad flap taken from the upper lip, the latter being split in a direction parallel to its plane surface in such a manner as to free it of both its cutaneous and its mucous layers, and this separation extending to but not through the vermilion border. The flap thus obtained consists of that portion of the substance of the upper lip lying between its cutaneous and mucous surfaces, which, after being turned upward, was fixed by sutures to the previously-freshened upper margin of the defect; its raw surface is closed in by a flap taken from the cheek of either side. The plan of building up a new nose by tissues derived from the upper lip has never found favor with surgeons, for the reason that these tissues are very unstable, and but an indifferent result is obtained at the best.

After-treatment in Total Rhinoplasty from the Frontal Region.—The hemorrhage is quite profuse, although not sufficiently so to involve danger to life. Repair of the frontal defect now takes place, in part by first intention and in part by granulation. Failure of the former over the exposed periosteum sometimes leads to necrosis, but this rarely separates, the granulations from the diploë gradually taking the place of the necrotic tissue. The cicatrix which finally forms, as a rule, does not produce marked deformity.

Gangrene of the newly-formed nose is not common. Sensation in this part is at first referred to the forehead; this changes later on. Care must be taken to maintain the nasal apertures patent: there is considerable tendency for these to contract. Tampons of antiseptic gauze are employed to prevent this at first, and later on metal tubes are introduced. These should be worn at night for some time afterward. Sufficient normal mucous membrane usually remains to maintain the sense of smell. The pedicle should not be divided, but after some months, if sufficient elevation remains to constitute a deformity, portions may be excised.

The Elevation of the Tip of the Nose.—The subsequent depression of the tip of the newly-formed nose sometimes requires measures of correction secondarily. Langenbeck attempted this by sawing strips of bone from the lateral walls and bending them so as to serve as rafters of support for the nose. The attempt rarely proves successful. Hueter split the tip of the nose, drew apart the edges of the incision so as to form a V-shaped cavity, and transplanted into this a portion of the integument from the plantar surface of one of the toes.

Frames of gold, platinum, and lead have been resorted to to maintain the tip of the nose in position, with varying degrees of success. As a rule, they are finally abandoned on account of the irritation which they produce. Leisrink successfully employed a light frame of yellow amber, upon which the frontal flap was placed. Celluloid may prove, upon trial, useful for this purpose.

Partial Rhinoplasty.—Dieffenbach declared that rhinoplastic operations are the more difficult the smaller the parts to be restored. The skill of the surgeon will be taxed to its utmost in taking proper advantage of the conditions as they present themselves. Strictly speaking, almost any rhinoplastic procedure is partial; whatever remains of the original nose, whether of alæ or septum, is to be carefully preserved under all circumstances.

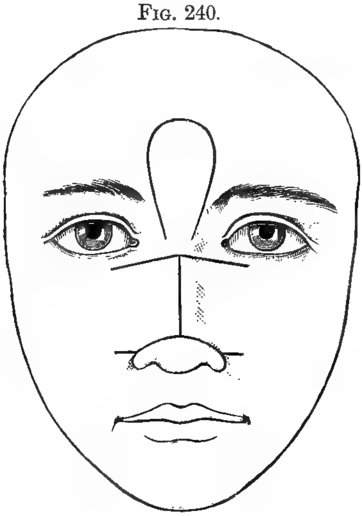
Reduction or Replacement of Displaced Ala.—Cicatricial inward displacement of an ala is rather a frequent sequence to syphilis. The ala should be loosened by means of the knife, placed in correct position, and united with a frontal flap, while kept in proper shape by tampons, etc. The shape of the frontal flap must be modelled to suit individual cases.

Sunken Nose.—Dieffenbach recommends the following method: The skin of the sunken nose is separated in the median line, and an oblong flap from the frontal region implanted between the wound-edges. After healing, both halves of the nasal skin, which have been pushed to either side in order to unite with the flap-edges, are dissected loose from the edges, separated as far as necessary, even upon the cheeks, brought together in the median line, and sutured together over the freshened frontal flap.

A modification of Dieffenbach's operation consists in bringing down the frontal flap in a reverse manner—*i. e.* turning the skin surface so as to look toward the nasal cavity, and immediately suturing the lateral skin-flaps over the raw surface, now uppermost.

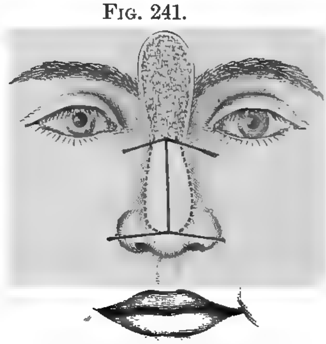
Verneuil's Operation.—This operation was suggested to M. Verneuil by M. Ollier for a case in which the patient had discharged a pistol in his mouth, destroying a portion of the hard palate and septum, the nasal bones, part of the nasal processes of the superior maxillæ, the spine of the frontal, and the anterior wall of the frontal sinuses. As a result of this, the parts were greatly sunken; the alæ and tip were uninjured, although much flattened (Jacobson). A vertical incision was made along the median line of the depressed organ, and a transverse one at each end of

Fig. 240.



Verneuil's method of rhinoplasty: the lines of incision.

Fig. 241.



Verneuil's operation of rhinoplasty for sunken nose.

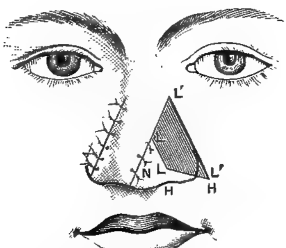
this (Fig. 240). The two flaps thus marked are dissected up and turned back. An oblong flap is now raised from the middle of the forehead and left adherent between the eyebrows. This is now turned (not twisted) downward, its skin surface being turned toward the nasal cavity, and fixed in position by a few sutures. The two lateral flaps previously dissected up are now drawn over the raw surface of the frontal flap and united by sutures in the median line (Fig. 241). The wound in the forehead is closed as far as possible, and any granulating surface left subsequently skin-grafted. The pedicle of the frontal flap is divided and trimmed at a later period.

Jacobson modified the procedure for a case in which the nose had been extensively destroyed by the combined effects of lupus and a quack ointment and plaster, but in which the bony parts were almost intact, by refreshing the skin surface of the forehead flap before placing it in position.[1]

Saddle Nose.—F. Koenig's method consists in separating the cartilaginous from the bony portion of the nose by a transverse incision, restoring the shape, and filling in the defect by means of an osteoplastic flap taken from the frontal region. The latter is reversed in turning it downward in such a manner as to place the skin facing posteriorly, in toward the nasal cavity. A second frontal flap is dissected up and brought down, with its pedicle twisted in the usual manner, and placed over the first. The two raw surfaces thus come together. The flaps are sutured in position separately. Final trimmings and corrections of shape are matters of after-treatment.

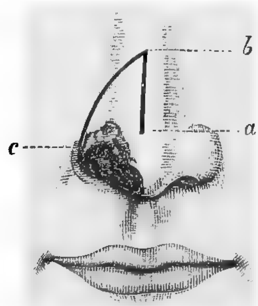
Formation of Ala of Nose.—This is usually required to correct the ravages of carcinoma. Langenbeck operated as follows: A quadrangular defect remaining, following extirpation of the right ala, a rectangular flap of skin, left attached near the root of the nose, is dissected from the

FIG. 242.



Langenbeck's method.

FIG. 243.



Denonvillier's method.

lateral surface and ala of the left side, brought over to cover the defect, and sutured in place (Fig. 242). Care should be exercised in dissecting the skin from the remaining ala, to which it is closely attached, that the perichondrium is not injured on the one hand, nor the flap button-holed on the other. The surface from which the flap is taken heals over by granulation. The final result is sometimes excellent.

[1] *Operative Surgery*, p. 256.

Denonvillier's Method.—In this operation a triangular flap with a pedicle is dissected from the sound tissues of the nose above the defect. An incision is made, commencing from near the tip of the nose and toward the sound side, and is carried upward nearly to the root (*a b*, Fig. 243). A second incision, commencing at the upper termination of the last named, descends obliquely downward (*b c*), and terminates at the upper and outer angle of the defect of the ala. This flap should be so arranged that when dissected up the pedicle or lower portion should contain a section of normal cartilage from the tip of the nose.

Weber's Operation.—In this operation the formation of a new ala is accomplished by cutting an oval flap from the centre of the upper lip, the pedicle of which is left attached at the columna: the free margin reaches to the prolabium; only a part of the thickness of the lip is utilized in the flap. The flap is turned upward and sutured in position to the margins of the defective ala, which have been previously freshened. The pedicle is divided at the end of three or four weeks, and is applied to the inner surface of the flap, so as to give a thicker and rounder margin to the new ala (Treves).

Total Rhinoplasty from the Arm.—*Italian Method.*—This operation is rarely performed at the present time. An exact imitation of the nose and septum cannot even be approximated, and at best a cicatricially shrunken mass of skin is implanted in the region of the nose. The excessively awkward, and even painful, position of the arm cannot be borne, and, save in very rare and exceptional cases, the procedure is practically abandoned.

Tagliacozza's Operation.—This consists, essentially, in making two parallel incisions over the middle of the biceps muscle, and dissecting up the skin between these, thereby obtaining a flap of skin attached by a pedicle at either end. Dressings are packed beneath this, and at the end of a week, when granulations have formed upon the posterior surface, the upper pedicle is separated. The flap is now permitted to shrink still more, in order to thicken and assume somewhat the shape of a nose, when, at the end of the third week, it is implanted into the defect. The arm is brought into position, and there maintained for eight days, at the end of which time, vascularization from the facial skin being completed, the remaining pedicle is separated and the arm released.

Von Gräfe's Modification.—This is the so-called German method. It shortens the time of the operation, but this is no particular advantage, for the reason that the most trying part of the procedure to the patient, the position of the arm, remains as before. The modification consists in making but one pedicle and implanting the flap at once.

The French Method.—This is preferable to the Italian method or that of Tagliacozza: the latter should be employed as a last resort only. The surgeon should be familiar with both, however, in addition to the Hindoo operation, or that of taking the flap from the forehead, for the reason that lupus and syphilis may destroy the skin of the forehead.[1]

Plastic Operations upon the Septum.—The septum is rarely destroyed by syphilis without simultaneous involvement of the ala. In

[1] Even under these circumstances Langenbeck recommends separating the cicatricial skin tissue and periosteum, and forming a flap thereby. The success of such a procedure must be very doubtful indeed.

those rare cases in which it becomes necessary to rstore the septum exclusively, one of the following procedures may be resorted to:

The Italian Method.—This method is not frequently employed at the present day. It consists in dissecting a flap from the palmar surface of the hand, instead of from the arm; the rest of the procedure is similar to that employed in total rhinoplasty from the arm.

Dieffenbach's Method.—This method consists in removing a portion of the upper lip throughout its entire thickness, and reversing it in placing it in position: the mucous membrane soon becomes hardened by exposure to the air, so as to resemble skin. It does not form a very firm support to replace the septum, and in females, who cannot grow a moustache to cover the lip deformity, the improvement is not sufficient to compensate for the latter.

Hueter's Method.—In accordance with the principles of Langenbeck's operation for restoring the ala of one side by implantation of the skin covering that of the opposite side, Hueter advised the formation of a septum from the skin covering the bridge of the nose. The flap is shaped in a somewhat oblique direction, which facilitates its rotation into position from the tip of the nose toward the lateral wall. The upper portion of the flap may include the periosteum, a more substantial support resulting. The rotation of the pedicle, occurring at the very tip of the nose, seems to assist in elevating this portion, which is usually considerably sunken by the loss of the septum.

Syndactylism.

Bridges of tissue are sometimes developed between two fingers, forming a lateral union by means of soft parts or, more rarely, cartilage. The most common form encountered is that in which integumentary tissue alone forms the medium of union, and is known as *webbed fingers.* The deformity is either congenital or acquired. The congenital cases are due to an arrest of the process that deepens the grooves between the tubercles which represent the site of the fingers in the rudiment of the hand in early fœtal life. The acquired cases are those of cicatricial webbing caused by burns. Here the web is very short and thick.

The web may be partial or complete, in the former extending to or slightly beyond the interphalangeal joint, or the fingers are united to near their tips. The fingers may be closely united by a short web, or the latter may be sufficiently long to permit of some freedom of motion. The fold of skin forming the web in the membranous variety has its base, which is usually concave, toward the free ends of the fingers, and its apex at the interdigital space. A slight increase in the interdigital fold, not sufficient to constitute webbed fingers, is sometimes observed, and gives the hand the appearance of having very short fingers.

The inner fingers are most commonly united, particularly the ring and little fingers. Any of them may be joined, however, although it is very rare to find a thumb united to the index.

Treatment.—Where the web is such as to closely unite the fingers the functional disability is an indication for operative interference. Even where the web is sufficiently loose to permit of considerable motion the deformity is unsightly and treatment is demanded. The methods of

operation formerly practised, such as simple division of the web by the knife or scissors, were followed by recurrence, the cicatricial tissue commencing at the apex of the triangle between the separated fingers and reuniting the latter. Slow separation by the wire écraseur, Maisonneuve's clamp (which resembles in its action Dupuytren's enterotome), and Lister's method by the elastic ligature give equally unsatisfactory results.

Operation by a Permanent Opening at the Base of the Web.—Rudtorffer formed a cicatricial opening resembling the ear-ring opening in a woman's ear. He employed a lead button for the purpose of maintaining the patency of the opening until cicatrization was completed, after which the bridge of skin was divided for the remainder of its length. The after-treatment consists in keeping the fingers well apart by the interposition of dressing materials. A silver or gold ring may be used instead of the lead button. One end of the ring may be sharp and the other hollow, and the two ends fitted together after introduction.

Didot's Operation.—Didot's operation consists in an attempt to obtain palmar and dorsal flaps of skin with which to cover in the wound surface of each finger after separation. The separation is effected in such a manner as to obtain two longitudinal flaps, which are dissected up as thick as possible, the one from the palmar and the other from the dorsal aspect of the affected fingers. An incision is made along the middle of the palmar surface of one finger, and is joined at each end by short transverse incisions to form a flap. A similar proceeding is carried out

FIG. 244.

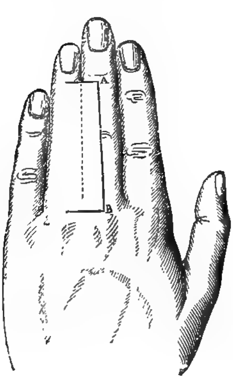


FIG. 245.

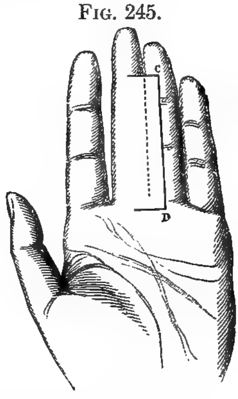
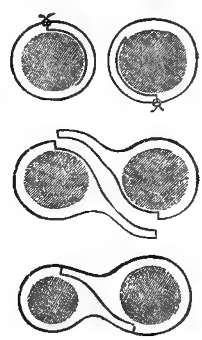


FIG. 246.



Didot's operation for webbed fingers.

on the back of the other finger. Two flaps are thus obtained, and at the same time separation is effected. Each flap is then folded round to cover in the raw surface of the finger to which it is attached, and secured by fine sutures. (See Figs. 244, 245, 246.)

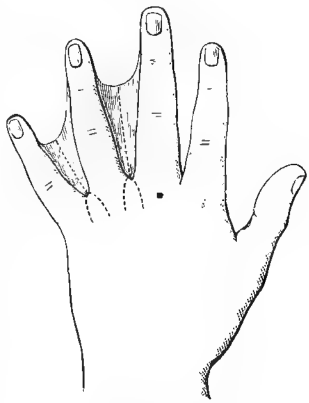
I have encountered two obstacles to success in this plan of operation. First, in membranous web-fingers the substance of the web is not sufficient to permit of the necessary splitting to form the flaps without impairing the nourishment of the latter. Second, in spite of the most careful watching, commencing recontraction at the interdigital cleft may lead to recurrence. Special precaution is required, as pointed out by Annandale,

to avoid interference with the functions of the fingers by making the flaps too broad. Encroachment upon the palmar and dorsal surfaces by the incisions will lead to impairment in the one of flexion, and in the other of extension, by cicatricial formation.

Dec's Operation.—This operation may be practised in cases where a large web exists. A fold of skin is raised by the aid of a mouse-toothed forceps near the base of the web and dissected toward the commissure. The fingers are kept well apart, and on cicatrizing the tongue of skin formed from the base of the web retracts and forms a new commissure.

Norton's Operation[1] (Fig. 247).—This operation is carried out somewhat upon the lines of Dec's, but is an improvement upon the latter. Small triangular flaps are raised at the clefts on the dorsal and palmar aspects. The webs are then divided, all tissues being thoroughly severed up to the bases of the flaps, which are then carefully joined together at their apices without tension. Every effort must be made to effect rapid union. The flaps should be thick in order to ensure a proper blood-supply, sufficiently long to prevent tension when united, and somewhat narrow to prevent bulging. Any tissues between the knuckles should be removed to let the flaps come well together. The apices of the flaps in young children are very small, and a fine needle should be used in the suturing. In arranging the position of the flaps care should be taken to observe the natural line of the web. The fingers should be kept well apart during the healing process.

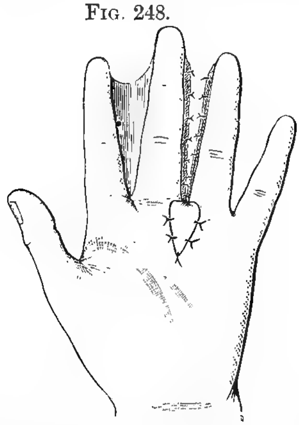
Fig. 247.



Norton's operation.

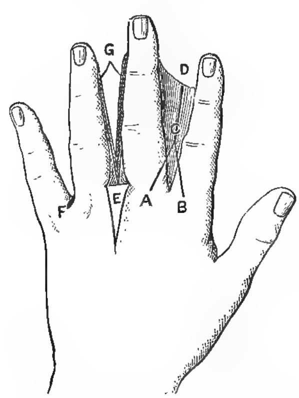
Agnew's Operation.—" A V-shaped piece is cut from the dorsal surface of the base of the web, the apex anterior. The flap, which

Fig. 248.



Agnew's operation, showing the flesh taken from the dorsal surface of the web and attached to the palmar surface after division of the web.

Fig. 249.



The incisions in Zeller's operation.

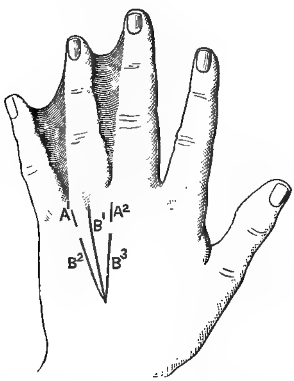
[1] *British Medical Journal*, 1891, vol. ii. p 931.

extends through one-half the thickness of the band, is next dissected back, and the remaining portion of the web slit longitudinally. The reflected flap is then drawn through the cleft at the base of the fingers, its apex stitched to the palmar surface of the wound, and its sides to the adjoining sides of the fingers (Fig. 248), at the same time closing the edges of the wound on each side of the fingers, keeping a strip of oiled silk between the fingers, and supporting the hand on a palmar splint."[1] This operation is almost identical with that next to be described.

Zeller's Operation.—Two incisions are made upon the dorsal aspect of the web and fingers, extending from the metacarpo-phalangeal to the first interphalangeal joints (*A B*, Fig. 249). The triangular flap thus obtained is dissected toward its base, and the remainder of the web is divided (*C D*). The fingers are now held well apart, and the reflected flap (*E*) is placed between the cleft and fixed by sutures to the palmar surface of the hand. The raw surfaces (*G*) are kept well apart by appropriate dressings. The union of the surface of the flap to that of the cleft obviates the tendency to contraction.

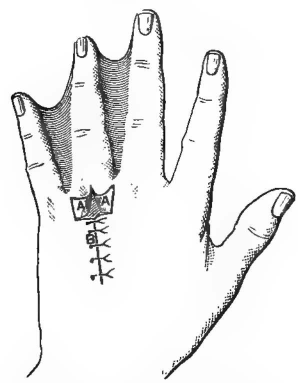
Fowler's Operation.—Finally, in cases in which failure has resulted from former operations, and considerable dense cicatricial tissue has replaced the original web, I have succeeded by dissecting up two narrow flaps from the back of the hand, and passing these through a buttonhole-like slit previously made in the line of the natural web and well up between the heads of the metacarpal bones (Figs. 250, 251). The flaps should be placed with their skin surfaces facing each other. Each flap is slightly rotated upon itself in order to pass through the buttonhole, and is made

Fig. 250.



Showing site of button-hole slits, A^1, A^2, and lines of incision, B^1, B^2, B^3, for the formation of the flaps.

Fig. 251.



The flaps, *A*, *A*, passed through the slits, and the gap from which the flaps were taken closed by a line of sutures, *B*.

Fowler's method of operation for webbed fingers.

sufficiently long to project a quarter of an inch or more upon the palmar surface, to allow for contraction. No sutures are required to retain these in position. The projecting ends upon the palmar surface are transfixed with a needle or hare-lip pin, and aseptic dressings applied. After a week the web is divided, when it will be found that the

[1] Agnew's *Surgery*, vol. iii. p. 371.

interdigital cleft is occupied upon either side by healthy integumentary tissue, which effectually prevents this from becoming the starting-point for reunion. Keeping the fingers separated by a layer of oiled silk, and careful aseptic after-treatment will ensure a good result. The method is equally applicable as a primary procedure. In case two webs are present to be dealt with, a slit should be made above the apex of each web, and one flap passed through each. Under these circumstances but one side of the cleft is lined with skin tissue, but this is ordinarily sufficient to prevent recontraction.

When the flaps are well attached the pedicles are to be divided. This may usually be done at the time of division of the web. The gap from which the flaps were taken, however, may be closed at once or at the first stage of the operation.

Supernumerary Fingers, or Polydactylism.—This is not of very uncommon occurrence and may be hereditary. Three forms are usually observed: (1) The supernumerary digit is rudimentary, may contain some cartilage, and is attached by a pedicle to one of the fingers or to the head of one of the metacarpal bones; (2) a fully-formed digit may articulate with the articular extremity of one of the phalanges, or with one of their lateral surfaces, or with a metacarpal bone; (3) a complete digit, with or without a separate metacarpal bone, may be joined to the entire length of a finger. If one metatarsal bone answers for both, the supernumerary digit articulates conjointly with its neighbor, and one capsular ligament and joint-cavity serves for both. Polydactylism is apt to occur in both hands, and symmetrically in the feet.

Treatment.—Supernumerary fingers are best dealt with by removal. There can be no question as to the propriety of this in the first two varieties; in the third surgeons were loath to operate because of the interference with the joint, and it was therefore thought best to amputate the extra digit distal to the articulation. The dangers of opening a joint having been reduced to a minimum by aseptic measures, this plan has been quite uniformly rejected, because of the unsightly stump which it leaves, and the supplemental finger (or toe) is removed entirely.

Congenital Deficiencies.—Numerical deficiencies, as well as those of size, are here included. One or more fingers may be missing, with or without absence of the corresponding metacarpal bones. Deficiencies of size are usually due to an absence of one or more of the phalanges of a finger. Congenital amputations are also included in this class. The treatment consists in amputation if the imperfectly developed finger be useless or in the way.

Congenital Hypertrophy of one or more digits may occur. This has been described by H. Fischer under the name of "*giant finger.*" The increase in size may be due to an excessive development of any of the tissues or only of the subcutaneous connective and fatty tissues. Rarely a single phalanx is involved. *Giant hands* and *feet* are features of the disease known among neurologists as *acromegaly*, or *Marie's disease*, which has been supposed by some to depend upon enlargement of the pituitary body.

Treatment.—Treatment by pressure bandages is useless, as when they are removed the growth is almost certain to relapse. Amputation may be resorted to if but a single finger is involved and this is in the way or

unsightly. If several fingers are involved and the affection partakes of the nature of *elephantiasis,* ligation of the main artery of the limb may be tried.

Bone-grafting.

The views formerly held that pieces of bone which were completely removed from their surroundings and then replaced or implanted in a distant part retained their vitality, and even underwent proliferation, are now known to be erroneous. The transplanted bone merely forms a scaffolding in the substance of which, after partial or complete decalcification has taken place, infiltration of bone-forming cells takes place. A. Barth of Marburg[1] in a series of experiments upon animals found that although bone thus transplanted became either encapsulated with fibrous tissue or healed in by osseous union, death of the fragment took place invariably. The replacement of the old bone by new does not take place by absorption of the former and subsequent growth of the latter, but a process of gradual substitution of living for dead bone, in which the osteoblasts penetrate directly into the substance of the bone, takes place.

Replacement of Bone after Trephining.—The question of replacement of buttons or fragments of bone after trephining has been settled in the affirmative. Numerous observers have recorded their experiences, and these have been, on the whole, favorable. The pieces upon removal are placed immediately in an aseptic salt solution until the stage of the operation is reached at which they are to be replaced. If the wound is an accidental one, the fragments removed are more or less covered with foreign matter, hair, etc. These must be washed thoroughly, and further cleansed, if necessary, by scraping with a bone-chisel or scalpel. They are then disinfected by means of a weak mercuric-chloride solution, and finally washed in an aseptic salt solution before replacement. If only a small amount of bone has been saved, the pieces are to be laid upon an aseptic surface and chopped into small fragments. These are to be evenly distributed over the dural surface.

Bone-implantation in Defects of Long Bones.—When a defect in a long bone whose continuity has been destroyed exists, the attempt is sometimes made to supply this by properly-shaped bone-grafts or bone-chips taken from a recently-amputated limb or removed from a living animal. In ununited fractures and shortening from loss of bone-substance the ends of the bones are freshened preliminarily, and a proper sulcus or groove prepared in the tissues between the fragments.

The chances of success in the latter class of cases are small. The causes, intrinsic in the bone itself, which prevented union of the original fragments will be almost certain to prevent union between the implanted and original bone.

Sliding Operations.—These consist of attempts to fill in defects of bone by either displacement of a bony part in its entirety—such, for instance, as dividing with the chisel a strip of hard palate with its coverings parallel to the fissure in cleft-palate, and crowding this over to the median line, and there securing it to a similar bony flap prepared

[1] *Verhandlungen der deutschen Gesellschaft für Chirurgie,* April 12, 1893; *Centralblatt für Chirurgie,* July 29, 1893.

in the same manner from the opposite side—or a layer of bone may be separated and transplanted with its entire skin-covering, as, for instance, from the frontal bone in forming a new nose (König). J. Wolff[1] proposed to fill in bony defects by separating a layer from the neighboring bone and sliding it into the defect by means of the loose fibrous connection between the periosteum and skin. Wolff reports, among others, three successful operations for "saddle nose" by this method. Curtis employed a similar procedure successfully in a case of defect of the tibia following compound fracture and necrosis. In this case the desired length of bone to fill the gap was obtained from the fibula in several pieces, owing to its having been previously fractured. The pieces were pushed through an opening made between the muscles and inserted in the gap in the tibia.[2]

Elongation of the ligamentum patellæ has been successfully treated by subcutaneous *transplantation of the tubercle of the tibia*, with the attached tendon, to a point lower down on the bone.[3] In old cases of fracture of the patella, in which shortening of the ligament prevents proper replacement of the lower fragment in the operation of wiring, the tubercle may be displaced in an upward direction by a similar method of transplantation (Volkmann).

Bone-grafting by Decalcified Bone.—This method, devised by N. Senn, consists in the implantation of bone-chips and bone-plates, previously decalcified, in aseptic bone-cavities and defects left by trephining.

Preparation of the Bone.—The compact layer of the fresh tibia or femur of the ox is used for the purpose. The periosteum and medullary tissue are removed, and the bone is sawn into longitudinal strips about an eighth of an inch thick. These strips are immersed in a liberal quantity of a 10 to 15 per cent. solution of hydrochloric acid in water, which must be renewed daily for from one to two weeks. They are then to be washed thoroughly in water or a weak alkaline solution, immersed for forty-eight hours in a 1 : 1000 mercuric-chloride solution, and finally placed for permanent preservation in a saturated solution of iodoform in ether. The pieces intended to be used as bone-chips should be cut into small pieces before immersing in the sublimate solution.

When the bone-grafts are to be used the pieces selected for the operation are wrapped in aseptic gauze and immersed in alcohol to dissolve out the ether and iodoform. They are then immersed in a 1 : 1000 mercuric-chloride solution, and just before being placed in position they are to be carefully dried with iodoform gauze.

Preparation of the Cavity or Defect.—The cavity or defect is to be thoroughly cleansed by curetting, and sterilized by repeated flushings with a 1 : 2000 solution of mercuric chloride,[4] scoured by means of aseptic gauze, and finally dusted carefully with iodoform. H. Dreesmann of Bonn secures asepsis by filling the cavity with olive oil into which is

[1] *Deutsche medizinal Zeitung*, Berlin, June 5, 1893.
[2] *Am. Journal Medical Sciences*, July, 1893, p. 30.
[3] Walsham, *British Medical Journal*, Feb. 18, 1893.
[4] *Deutsche medicinische Wochenschrift*, May 11, 1893.

plunged the glowing point of a thermo-cautery, thus bringing the oil to the boiling-point.

Filling the Cavity or Defect.—The cavity or defect is now to be filled in with the bone-chips or plates. In case an irregularly-shaped cavity is to be filled, the bone-chips are packed in carefully until the gap is filled. A capillary drain is placed at the most dependent point, and the periosteum and soft parts are united with buried animal sutures. If a defect of the soft parts is present, an iodoform-gauze compress is placed over the defect to hold the bone-chips in position.

In cases of openings or gaps in the skull, these are to be filled with plates cut from decalcified bone to fit. These should be perforated to facilitate drainage.

The superiority of the method of bone-grafting by means of decalcified bone over that of completely detached bone has been attested by instances in which cavities have been treated by the simultaneous implantation of decalcified bone and fresh fragments of bone from the patient's own body. Not only have the former been found to be superior for this purpose, but the latter, it is believed, actually hinder the healing process.[1]

[1] A. G. Miller, *Lancet*, Sept. 20, 1890.

MILITARY SURGERY AND THE CARE OF THE WOUNDED ON THE BATTLE-FIELD.

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I. New Conditions arising from the Introduction of Aseptic Surgery and Modern Firearms.

Since the close of the last great war among civilized nations a change has taken place, no less radical and complete in surgical methods than in the character and efficiency of military weapons. The old treatment of wounds and the technique of operations have been revolutionized by the discovery and general application of antiseptic principles, while in the mean time the old lead small-arm bullet, which has made the vast majority of the gunshot wounds in all modern wars, and with the effects of which military surgeons are so familiar, has been replaced by another totally different missile of great but still uncertain capabilities. The grand results which have been achieved through recent improvement in general surgery are well known. What effect the introduction of the new weapons will have upon the character of gunshot injuries and on the care and handling of the wounded is not yet fully determined. The experience and the literature accumulated during former wars are based almost wholly upon the results of the old surgery with the old weapons now obsolete.

The effects of the new infantry rifle projectile on animate and inanimate objects have recently been the subject of most elaborate study by surgeons in this country and abroad. Experiments on the cadaver show the mechanical action of the new projectile on dead and more or less deteriorated animal structures, as well as the effect of these structures on the stability of the bullet; but there are many important questions of the utmost interest to the military surgeon upon which they can give no evidence. The tearing and mangling produced upon decayed muscles and putrid viscera can hardly be the same as upon those organs in the living state. The flaccid and inelastic condition of dead skin must certainly have an influence on the size and appearance of wound-openings. Experiments on the cadaver furnish no evidence as to the percentage of mortality, immediate or remote, in any class of injuries, nor as to those important factors in gunshot wounds, shock and hemorrhage, nor of the results of treatment, the occurrence of suppuration or of septicæmia.

It is evident from present indications that the small-calibre bullet, which must eventually be adopted among all nations, will be one which is practically indeformable against animal structures and almost

identical in ballistic qualities—alike in form, weight, calibre, and velocity, and alike for the rifle, the carbine, and the machine-gun. The factors which enter into the causation of gunshot wounds from these missiles will thus be so constant and uniform as to produce far more constant and uniform results than have been observed with the old deforming lead bullet. The difference between these two, as stated by Delorme and Chavasse, lies mainly in the greater force of penetration, greater stability, and smaller diameter of the former. There can be no doubt that the new bullet will exert a more definite effect on the tissues than did the old, whether more fatal in the long run or less. There will be fewer doubtful cases. The great difficulty in determining the prognosis of gunshot wounds made by the old bullet was the uncertainty as to what complications might exist. Even when the wounds of entrance and exit were clearly marked, there could be no assurance that a part of the lead, or pieces of the clothing or other foreign matter were not left concealed in the tissues. That the small-calibre bullet rarely remains in the body when fired from any distance within the effective range of the rifle, that it rarely deforms even on impact against resisting bone, and rarely carries clothing or infectious material into the wound, are new features of the greatest importance to the surgeon and the patient.

As the modern rifle projectile has a greater velocity, a flatter trajectory, and consequently a wider range within the ordinary height of a soldier than the old, and as it is capable of penetrating the human body, or even five bodies in a direct line, without regard to the structures intervening, as shown in the experiments of Bruns and others, and as a greater number of the small cartridges can be carried in the belt and fired with greater accuracy and rapidity than formerly, it may be assumed that there will be a greater number of men wounded on the battle-field within a given time in future wars than have been in the past. Tactical changes must be made to meet the new conditions. Lines of battle will no doubt be greatly extended, distances on the field will be vastly increased, and the wounded will in consequence become widely scattered. Engagements will open at longer ranges, and, with the use of relatively smokeless powders, they will proceed with greater accuracy of aim and more destructive effect. Battles will be shorter, sharper, and more decisive, and campaigns with all their disastrous consequences of sickness from camp and epidemic diseases will be less prolonged.

The ratio of killed to wounded appears likely with the new weapons to be increased. The long, clean cut, non-contused tracks of the small-calibre bullet favor internal hemorrhage, one chief cause of mortality in the field. But, on the other hand, for those who survive the immediate effects of their injuries these wounds, with their small valve-like openings that readily close, are also favorable to healing, and thus the ratio of recoveries to the number of wounded will likewise be increased, while the percentage of secondary mortality and the number of permanently crippled will be reduced, both through the more favorable character of injuries by the new projectile and through the new aseptic methods in surgery.

Much stress has been laid upon the effect which the long range of

modern firearms is expected to have upon the facilities for removing the wounded from the field. Professor von Bardeleben has recently said, in substance: "The first and most difficult task will be to remove without delay the enormous number of wounded out of the fire-line. Who will be able to tell beforehand where bandaging-places will be out of reach of the enemy's fire? Some urge an increase of sick-bearers and wagons, but this also increases the number liable to be wounded, and in order to effect an uncertain saving of one human life exposes the lives of a number of other men to danger." Battles are rarely fought on level, unobstructed plains; distances therefore between the line of battle and the dressing stations or field hospitals are not measured in yards; they are determined by the physical and topographical features, natural and artificial, of the region in rear of the battle-field. These may sometimes be very favorable, or they may be in the highest degree unfavorable, to the care and removal of the wounded. Ambulance wagons can only be brought to the front under cover of some natural object which may offer protection against artillery and infantry fire; otherwise the injured, unable to walk, must remain in sheltered places until opportunity offers for their removal. It will be quite impossible with any reasonable number of bearers to carry the usual proportion of seriously wounded from the field on litters to a point beyond the reach of modern artillery field or siege rifles, since these weapons are capable, with the new powders, of exploding shells with considerable accuracy against visible objects at a distance of from three to five miles. This seems to indicate the necessity for plenty of surgeons and attendants at the various collecting stations or nearest places of safety where the wounded may be held and cared for during the prevalence of the "traumatic epidemic" of battle, and perhaps for some time after. It has been suggested by eminent authority that under the new conditions, plans for the immediate removal of the wounded from the field should be given up and efforts made to provide temporary hospital accommodation for them in such places as may be practicable near at hand.

II. Field Organization.

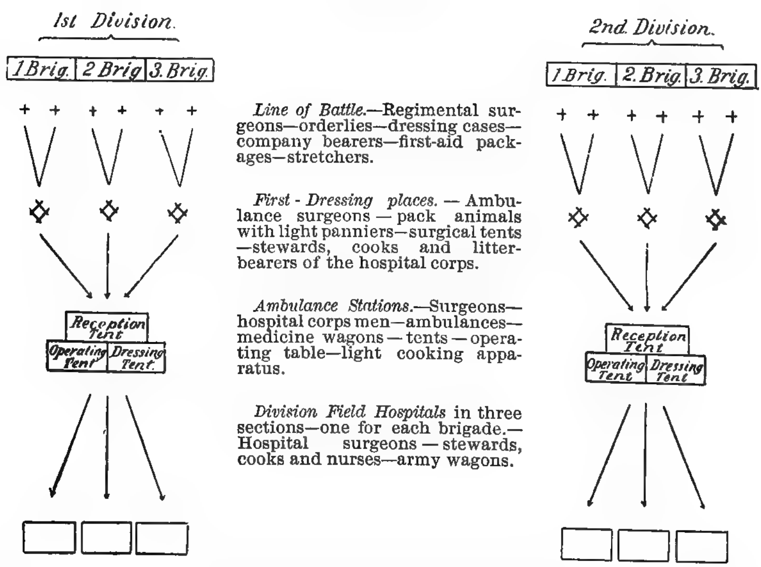
A well-organized system for rendering prompt aid to the wounded on the field now forms part of the military establishment of every civilized nation. These systems are identical in principle and differ only in matters of minor detail. The original prototype of all is to be found in the "ambulance volante" of Baron Larrey, which Napoleon said was "the happiest conception of the age," and in the brancardiers of Baron Percy.

The organization maintained in time of peace is so constructed as to be capable of expansion and readjustment to meet the necessities of war. The medical officers, who have been stationed at the barracks and hospitals or elsewhere, are, on mobilization of the army, assigned to the different administrative and executive duties with the corps, divisions, and regiments, or to the division hospitals and ambulance companies, for the campaign. The hospital corps, which has been thoroughly instructed and drilled in the use of the litters and ambulances, in the handling of the wounded, and in the care and feeding and nursing of the sick, is now

organized into two separate and distinct detachments—one for duty with the field hospitals and the other to man the ambulances and litters for the collection and removal of the wounded from the field.

United States Army.—The materials for a very comprehensive and efficient field service are at hand in the United States army, and the general plan of the work is outlined, but many of the practical details are left to be arranged when the necessity shall arise. The regulations provide that in time of war "the privates of the corps to perform the duties of litter-bearers, service with the ambulances, and at dressing and ambulance stations should number at least 2 per cent. of the aggregate strength of the command," and that "to every ten privates there should be an acting hospital steward, and to every thirty privates a hospital steward." As an auxiliary to this corps it is further provided that "there shall be in each company four privates designated for instruction as litter-bearers." They retain their status as combatants, being selected merely to "give first aid to the wounded or to carry them to the rear until relieved by the members of the hospital corps," after which they resume their arms and their places with the troops. The ambulance and hospital services of each corps are under the supervision of its medical director. The wounded are to receive attention—first, on the line of battle; second, at the first-dressing places; third, at the ambulance stations; and fourth, at the division hospitals. The first-dressing places are to be established at the nearest point to the combatants where the wounded and those caring for them may not be unnecessarily exposed to

FIG. 252.



Schematic diagram showing theoretical arrangement of the several lines of medical aid on the field.

fire. Ambulance stations will be established at some place of security in rear or in some convenient building near the field. The division hospital will be located by the medical director after consultation with the

commanding general. Two-horse ambulance wagons, "equipped with such number of stretchers and other appliances as may be prescribed by the surgeon-general," are provided on the basis of three to each infantry regiment of five hundred men or more, two to each cavalry regiment of like strength, and one to each battery of artillery; two such ambulances to the headquarters of each corps, and to each division train of ambulances two army wagons. Corps ambulance medicine wagons are contemplated, but their number, contents, and distribution are left for future determination. The ambulance wagons of the corps are organized by authority of the medical director into trains for the different divisions and brigades, and a suitable number of officers of the line are to be detailed to take charge and handle them on the field as may be required by the medical officers in the collection and removal of the wounded. The privates of the hospital corps in the field in time of war will be organized into a company for each brigade, with their hospital stewards and acting hospital stewards, under the command of a medical officer. They camp near the division, brigade, or field hospital with the ambulance train, to be in readiness for service when needed.

English Army.—As at present laid down in British regulations, an army corps numbering 37,431 of all ranks has with it 105 medical officers all told, and 798 non-commissioned officers and men of the "medical staff corps." With a fighting strength of 35,000 men this gives 1 medical officer to 333 combatants. There is one bearer company and one field hospital to each of the six brigades.

A *bearer company* has 3 medical officers and 64 non-commissioned officers and privates of the medical staff corps, 1 officer and 36 enlisted men of the "army service corps," with 10 two-horse ambulances, 2 carts, and 2 wagons.

The *field hospitals* have 100 beds each, with 4 medical officers and the usual personnel and transport.

In *action* the bearer companies are formed into two sections, under 1 medical officer, of 1 sergeant and 16 privates each; 5 corporals and 3 privates, in addition to the drivers, serve with the ambulances; 1 sergeant is placed at each brigade "collecting station," and 2 medical officers, 4 non-commissioned officers, 1 bugler, and 3 privates, including a cook and a tent for surgical operations, at each "dressing station." The ambulance wagons are likewise divided into two sections, one of which plies between the collecting and the dressing stations, and the other between the latter and the field hospitals. Each battalion of infantry and regiment of cavalry is provided with a medicine cart, which carries to the field the stretchers for the company bearers. A corporal orderly remains with each cart and the two panniers and circular surgical tent, while the private orderly takes from the cart his field companion and surgical haversack with the two water-bottles, and at the same time the company bearers fall out, place their kits on the cart, take the stretchers, and report to the battalion or regimental surgeon.

European Armies.—The sanitary organizations of European armies are all constructed on the same principles and are very similar. A German army corps of twenty-four battalions of infantry 1000 strong has three "sanitary detachments" and two in reserve, with 1 captain and 2 lieutenants of the line, 7 medical officers, 3 petty officers, 159 stretcher-

bearers, 48 non-commissioned officers and privates of the "sanitary corps," and 31 "train-men" to each; also 8 ambulance, 2 medicine, and 2 baggage wagons, all two-horse, and 56 stretchers on the ambulance wagons. There are 12 field hospitals to a corps and 6 in reserve, of 200 beds each, with 1 surgeon in chief, 1 staff surgeon and 3 assistants, and 21 attendants. Two medical officers are supposed to be with each battalion of infantry and regiment of calvary, and one with each battery in the field. The orderly knapsacks are brought to the front on the pharmacy wagons, and are carried on the field, with infantry and cavalry alike dismounted. In the Danish, Belgian, and Russians armies orderlies carry the medical knapsacks also on the march.

In the Austro-Hungarian army each infantry division of 18,000 men has a "sanitary detachment" of 2 line officers and 95 men combatants organized to form two first-aid stations, one dressing station, one "ambulance" and one "sanitary material reserve," also supplemented by a sanitary column of the German order of Knights. The "ambulance" has 3 surgeons permanently attached; the other dressing-places are supplied during battle by the regimental surgeons. Field hospitals are organized one for every division of infantry, but they are not attached to the divisions. They remain independent, to be assigned wherever required. Every non-commissioned officer and soldier carries a small dressing package covered with sheet metal, containing 2 pieces sublimate gauze, 2 pieces oiled silk, 10 grammes cotton, 2 safety-pins, and a triangular handkerchief or 4 metres of bandage. Each stretcher-bearer carries a leather pouch on his waist-belt containing 10 dressing packets, 1 tourniquet, some cotton, a small cup, 2 triangular bandages, 5 safety-pins, and a pocket-knife; also 2 water-bottles. The "bandage-bearers" carry in action medical or surgical knapsacks brought to the field in the wagons, containing medicines, dressings, and surgical instruments. Each surgeon with the troops carries a leather pouch with two pockets containing some medicines and a small case of instruments.

The details of sanitary organization in European armies are important as examples for comparison and study, because they have in very recent years undergone thorough revision and improvement, the result of experience in war and to meet the new conditions presented by the introduction of modern firearms. Germany has been the leading power in these advancements, and other nations have closely watched and copied her methods, by which the various systems formerly in vogue have become more uniform in construction and more practically useful in operation.

III. Preparations for the Field.

The principal things to be considered in preparing for the field in time of peace are the training of the hospital-corps men and the company bearers; the selection and arranging of the most suitable instruments, medicines, and dressings in convenient form for use at the different points along the lines of medical aid; the preparation of tents, bedding, cooking utensils, furniture, and appliances for the field hospitals; and the organization of efficient means of transportation. All these important matters have received close attention of late years from the medical

departments of foreign armies, but, although great advancement toward perfection has been made, there is still room for improvement in many practical points.

The *hospital corps*, especially the more intelligent members—stewards and acting hospital stewards—should receive, among other things, very careful and thorough instruction in the principles of antiseptic surgical methods, and they should be so trained as to make them reliable assistants in time of operations. In military surgical practice on the field, whether at the dressing stations or at the hospitals, it will rarely happen that more than one or two medical officers are available for each operating table, and they will have to depend upon the hospital-corps men for the most essential and important assistance in many trying emergencies. The members of this corps will not all be found to possess a like aptitude for

Fig. 253.

Private, hospital corps, U. S. Army, field equipment (front view).

Fig. 254.

Private, hospital corps, U. S. Army, field equipment (rear view).

such service, but each one, while being instructed in the general duties pertaining to all, should receive some special training in the performance of those functions for which he is by nature best adapted. Some will

make better cooks than others, some better nurses; some can assist at operations, and others may only be suitable for litter-bearers or ambulance-drivers. There is reason to believe that in the vast amount of labor and pains devoted to perfecting these men in the litter drill the great advantages to be derived from special training in other branches have been overlooked. Litter-carrying is not the only function, nor the most difficult one, which the hospital corps will be called upon to exercise in the field. It will be equally important to have a few men who possess some degree of skill in the preparation of diet for the sick, in the dressing of wounds and the nursing of patients in the wards, and in the handling of instruments and dressings in the operating-rooms.

The *company bearers* perform their duties on the field under the orders of their own officers, and they should therefore be drilled and trained by their own officers. In order to ensure the presence at all times of four trained men to act as bearers and to be able to fill vacancies in case of accidents, the instructions should not be confined to any particular set of fours, but should be given alike to the entire company. The tactics as published for the bearer drill require no expert medical or surgical knowledge for their full comprehension, and the services of a medical

FIG. 255.

officer at these exercises are therefore not necessary. No instructions beyond those in bearer drill and in the various improvised means and

methods of transporting injured persons by hand will be required, as the *company bearers have no concern with the dressing of wounds.* Under present arrangements in modern armies stretchers intended for the use of company bearers are carried on the ambulance or medical wagons, which with large bodies of troops rarely reach the front in time to be of service during the early part of an engagement. Ordinarily, the company bearers will have to do most of their work as best they can without the aid of the regulation litter. Instruction, therefore, in other methods of carrying the wounded and in the construction of improvised appliances for this purpose will be of especial service to them, and it is, in fact, an essential part of their training. In the German army, in addition to the drill of the sanitary corps, a modified drill with elementary instructions in a few important methods of rendering first aid are given to all soldiers of a garrison. In the Swiss army the formation of fours as a unit for the handling of wounded on the field with the stretcher has been abandoned as unsatisfactory and impracticable, and the method of two bearers acting together has been substituted in its stead.

MATERIAL REQUIRED.—The important question as to what medical and surgical supplies will be most needed for the field must be determined from past experience and present knowledge after a careful study of all available facts bearing upon the character and relative frequency of the diseases and injuries to be treated. The accompanying Table I.,

TABLE I.

There were—	Officers.	Men.	Total.	Per cent.
Killed on the field	597	7,138	7,735	12.6
Slightly wounded	1,881	28,498	30,379	49.6
Severely wounded	1,353	21,701	23,054	37.7
Total	3,831	57,337	61,168	99.9
Remained with the troops after being wounded	688	5,972	6,660	10.9

extracted from Fischer's statistics of the killed and wounded in the Prussian army 1870–71, gives the gross results of 61,168 cases of shot injuries, from which it appears that in every 100 men hit, 12 were killed, 49 slightly and 37 severely wounded, and that 10 per cent. of

TABLE II.

Severely wounded.	Number.	Per cent.
Head and face	2,569	11.14
Throat	514	2.23
Chest	2,254	9.77
Back	793	3.44
Abdomen	1,890	8.20
Side	988	4.28
Upper extremities	5,628	24.41
Lower "	8,418	36.52
Total	23,054	99.9

the wounded remained with the command for treatment. The 23,054

severe wounds were distributed over different parts of the body, as shown in Table II. Turning to the records of the War of the Rebellion, in

TABLE III.

245,790 shot wounds, War of the Rebellion.	Number.	Per cent.
Penetrating wounds of the chest	8269	3.36
" " " abdomen	3717	1.51
Primary lesions to blood-vessels	485	0.19
" hemorrhage	110	0.04
Fractures of hip-joint	386	0.16
" of long bones, thigh	6738	2.74
" of the knee-joint	3398	1.38
" of long bones of the leg	9171	3.79
" of ankle-joint	1722	0.70
" of shoulder-joint	1579	0.64
" of long bones, arm	8245	3.31
" of elbow-joint	2816	1.15
" of long bones, forearm	5194	2.11
" of wrist-joint	1509	0.61

245,790 shot wounds the special injuries shown in Table III. were noted. These statistics are based on a large number of cases, and are therefore reliable.

Allowing for some difference in results to be obtained under the new conditions with the new armament, it is thus shown what percentage of men will be killed in battle, what proportion will be slightly or severely wounded, and the exact seat and character of all the graver injuries. Add to this about 1 per cent. for the usual accidents and from 3 to 5 per cent. for sickness, and there is all the information necessary under ordinary circumstances to guide in the selection of medicines, instruments, dressings, or other material and transportation to be taken to the field. The necessity for some means of immobilizing broken bones will be at once apparent. From two to three compound fractures of the thigh, three to four of the leg, three to four of the arm, two to three of the forearm, and one or more each of the knee- and elbow-joint may be expected among every hundred of the wounded.

Splints of light wire, which may be carried in the roll or in pieces of suitable size, are very convenient, especially for first dressings. The French surgeons speak favorably of this material. The coil given to it in the roll imparts additional strength in the longitudinal direction. *Plaster splints* are of great service in the field, but formal dressings of this kind consume time and require some skill and assistance in their application, and there is the additional disadvantage that they are difficult to utilize in damp or rainy weather. Instead of using the heavy plaster dressing alone, it is better to combine it with some other lighter material as a basis. Wire splints may be cut from the roll, and after being adjusted with proper padding beneath they may be secured by a couple of plaster rollers, or some other light splint material, or even extemporized splints out of reeds, brush, or twigs may be used in the same way. *Thin wooden splints* are very practical and easily carried. A number of these may be brought along in the mule panniers, and when applied under plaster rollers they make very firm support. Like the combination of wire and plaster, they are lighter and quicker to dry, and more

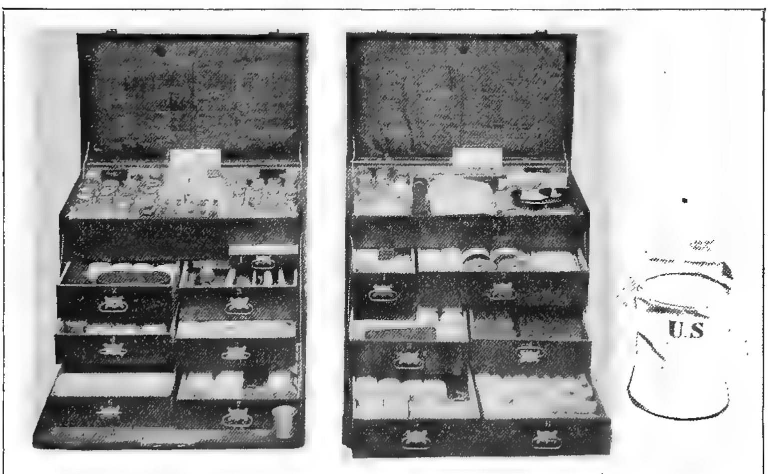
readily applied and much more easily removed, than the ordinary plaster splints for temporarily fixing broken limbs. Telegraph wire with the aid of a file or a file-backed knife has also been used for this purpose.

Extemporized splints are not to be relied upon too much in the field, for although there may be occasions and places where the materials for their preparation are at hand, this will often be found difficult or impracticable on account of the time and inconvenience involved in procuring them. When on an active campaign the troops happen to be in the vicinity of swamps or thickets where reeds, rushes, tall sedges, or the thin, straight shoots of such shrubs as the red osier dogwood or the euonymus or willow abound, the opportunity may be improved by having a few splints prepared to supplement the limited supply on hand. Guns, ramrods, and bayonets constitute the least desirable material for this purpose, and they are not always available, although a rifle may sometimes be utilized as the long splint on one side of a fractured lower extremity.

The application of splints requires a considerable quantity of other material for padding and bandaging, principally jute, cotton, gauze, and adhesive plaster. The latter may often be used on the outside to secure dressings in place with economy of time and material. All these articles should be in readiness for use in convenient parcels compressed into as small a bulk as possible—bandages cut and rolled, adhesive plaster on spools, and cotton and gauze in small cartoons. Expense cannot be considered in the preparations for war until after all other requirements have been satisfied.

Antiseptic and Aseptic Materials.—Medicines, instruments, and dressings must be selected to conform to the latest advancement in medical

FIG. 256.

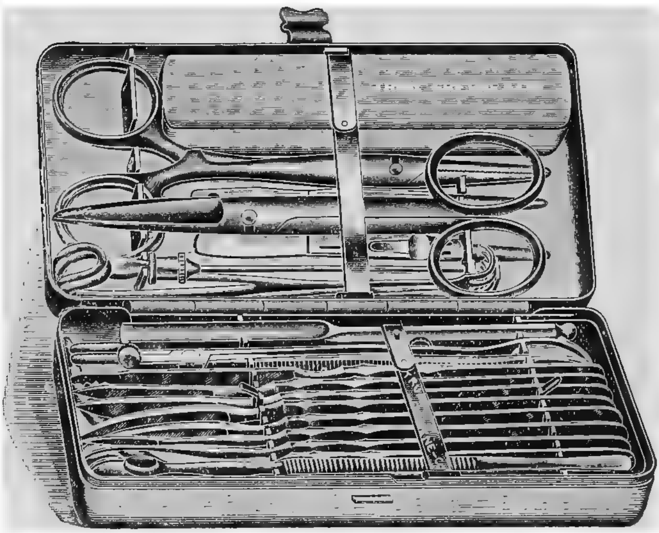


U. S. army regulation panniers, 1894.

and surgical practice. The demands of antiseptic principles are to be met in military surgery on the field as far as possible, limited only by the necessities and exigencies of warfare. The antiseptic agent most

extensively employed in the present status of surgical technique is heat. Fire and a limited amount of water can usually be secured on the field, and they can always be supplemented by such chemical antiseptics as the bichloride of mercury, carbolic acid, kresol, and others. Tablets composed of about 7.5 grains each of corrosive sublimate and the chloride of sodium or ammonium are very convenient for field use. One tablet to a pint of water makes a 1 : 1000 solution. Pure carbolic acid in crystals may be carried in small strong bottles, and, for convenience of measuring, it may be reduced to a liquid by the addition of a few drops of water when wanted. Trikresol, which appears to be a very valuable surgical antiseptic, or formalin occupies very little space.

FIG. 257.



Senn's emergency pocket operating-case.

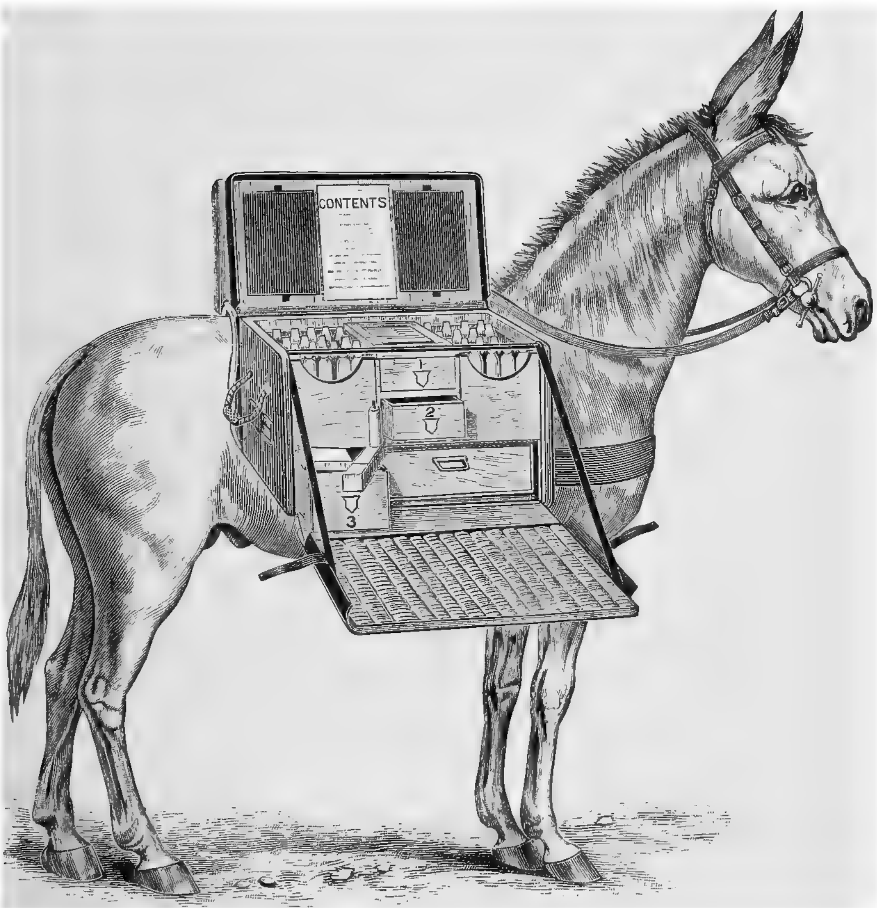
Catgut ligature for the field should be wound on small glass spools, and, after being sterilized by boiling in absolute alcohol, may be kept in bottles of absolute alcohol secured by rubber stoppers and caps. When the ligature is to be used, the cap and stopper are removed and one of the spools lifted out with forceps and placed in the operator's hand or in alcohol, or the thread may be drawn up from the bottle and cut as required, but it is never to be drawn through a hole in the stopper. The smallest bottle of catgut ligature for convenience at the front might be about an inch square by an inch and a half high, which will contain 3 yards of fine, $2\frac{1}{2}$ yards of medium, and 1 yard of coarse ligature on three glass spools. *Silkworm gut* may be carried dry, and sterilized by boiling with the instruments or otherwise, or by immersion in a 1 : 1000 bichloride solution as wanted. *Silk* ligature is best carried in the needle threaded and sewed into pieces of linen or cotton stuff in lots of from one to three or four dozen. These may be sterilized by boiling for a few minutes with the instruments. Bichloride gauze may be carried in small sealed packages with safety, but carbolated and

salicylated dressings are not reliable except when freshly prepared, nor are they in the least necessary in the field.

IV. Distribution of Material along the Lines of Medical Aid.

On the Line of Battle.—It is obvious that medical and surgical materials and appliances for field service must be especially selected and adapted to meet the needs of each particular point along the lines of medical aid for which they are designed. The dressing-case or pouch carried by the regimental surgeon's orderly is for use with troops away from all other sources of supply, and it should be equipped and kept

Fig. 258.

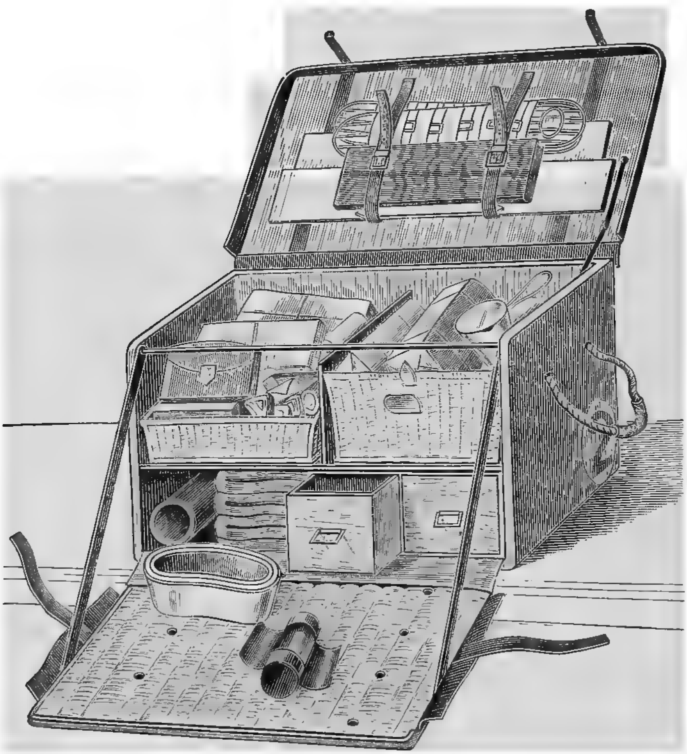


Medical pannier mounted.

for that purpose only. Sick and wounded men will be left behind when the troops advance, and there will be no demands upon its contents except for the treatment of such acute cases of illness or injury

as may happen on the march or in action. As the surgeon is obliged to remain with his regiment, he will have few opportunities for the performance of operations or to attend to sick or wounded men unable to keep up with the command. These conditions indicate at once what articles are to be supplied to the regimental surgeon and his mounted orderly. A few simple medicines for the relief of pain, shock, fainting, nausea, diarrhœa, heat, exhaustion, and the like; a pocket case of instruments for small operations; antiseptic tablets, carbolic acid, cocaine, chloroform, and bottle for anæsthesia; catgut, silk, and silkworm-gut ligature; wire or wooden veneer splints; plaster rollers wrapped and sealed separately in paper; compressed gauze, jute, gauze bandages, a spool of adhesive plaster, and a 2½-inch rubber bandage. By properly

Fig. 259.



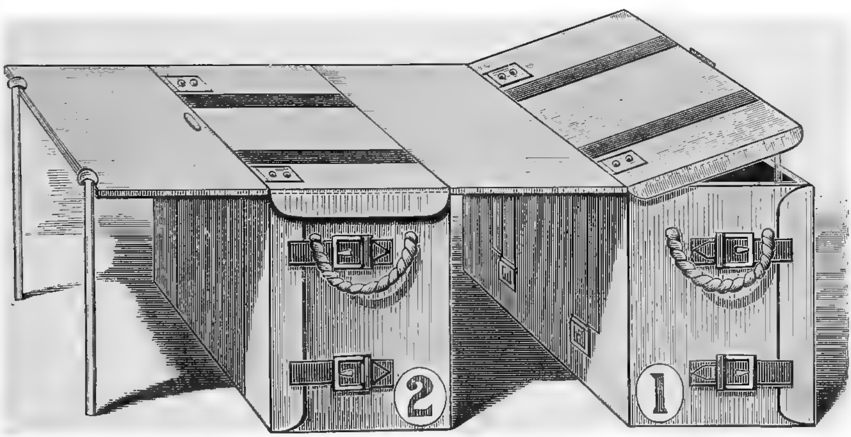
Surgical pannier dismounted.

regulating the proportionate amount of these articles, and with the frequent opportunities to renew what has been used, all of them can be carried and made available.

At the first-dressing places the articles needed include all those above named, but in much larger quantity, and with the addition of a case or two of well-selected and compactly arranged instruments for general operations, including the elevation of depressed fracture of the skull, tracheotomy, amputations, and the ligature of arteries; an operating

tent, a cook, and some sort of small portable cooking apparatus and condensed liquid nourishment. In many European armies the little first-dressing packages carried by the soldiers constitute the only aid provided for sick or wounded at the front until the medicine carts come up and bring the orderlies with their knapsacks, haversacks, and water-bottles and the stretchers for the company bearers. In our service the surgeon's orderlies are mounted and carry the pouches with them on the march, but there is nothing provided for the first-dressing places until the arrival of the panniers, which are carried on the ambulances; and this may not, and usually does not, occur until long after the engagement is in progress and the field is strewed with the wounded. Wheeled transportation cannot be depended upon to reach the scene of conflict until some hours after a considerable number of men have been injured and in need of assistance. To meet this necessity the French have, instead of the battalion medicine carts, *pack-mules* carrying panniers which keep well closed up with the troops. This arrangement is greatly needed in our army, not, however, to take the place of the brigade medicine wagons which serve as a base of supplies for distribution to other points, but in addition and auxiliary to them. At least one pack-mule with two light panniers should be provided to each brigade to supply material for the first-dressing places in the interval between the commencement of hostilities and the arrival of

FIG. 260.



Panniers as an operating table.

the hospital-corps men with the ambulance train. The surgical tent and at least two or three even of our present heavy stretchers might also be brought up on the mule. A light form of stretcher, with perhaps bamboo poles or one that folds and has a joint of separation transversely, is much needed for this particular purpose. The panniers serve for an operating table. The cook may be mounted and utilized to bring up the mule. Scarcity of water is often a serious difficulty at these places, but the surgeons may sometimes be able to locate them on the borders of a stream or near a well or spring.

Ambulance Stations.—The equipment of an ambulance station comprises some tents, which when practicable are pitched in connection with such local buildings or shelter as may be found available; a light field cook-stove and commissary stores; stimulants; concentrated food for the preparation of hot coffee, soup, and other nourishment; and the brigade medicine wagons supplied with instruments and appliances necessary for permanent or emergency dressings, and for such operations as circumstances require or as time and opportunity may permit. These stations should be so organized as to supply their own transportation in the ambulances entirely independent of the army wagons, in order that they may get to the field and into operation as early as possible after the trouble begins, and without waiting for the heavily-laden trains, which must necessarily be delayed. The value of medical aid on the field is often dependent upon the promptness with which it is rendered. The fate of many cases is determined by the earlier or later arrival of these light, quick-moving vehicles with needful assistance. Ambulance stations, like the division hospitals, are always to be located where there is a good supply of water, fuel, and, when practicable, hay or straw. There should be at least three medical officers and a sufficient number of hospital-corps men. The wounded are often obliged to remain at the ambulance stations during the first night and sometimes longer after a battle, and in case of victory the field hospitals may be located there, or when defeat is sustained the disabled may be collected and left there with a medical officer under the supposed protection of the Geneva articles of agreement.

Field Hospitals.—In our army a field hospital is organized to meet the requirements of each division, but it may be separated into its integral parts and distributed to the brigades or regiments when they are operating as independent commands. It is transported on army wagons. The tents, furniture, and most of the appliances appear by comparison to possess qualities which in point of practical utility are fully up to if not ahead of those of any foreign power. The light folding cots, chairs, and tables are especially noted for excellence and suitability to their purpose. The most desirable location for a field hospital during hot or even moderately cool weather is in the vicinity of large barns with adjoining sheds, which can be thrown open so as to furnish shelter overhead and a free circulation of air throughout. Around this the tents may be pitched, and with the sides raised conditions are obtained which admit practically of an out-door treatment for the wounded, under which, notwithstanding many apparent discomforts, they do far better than in close quarters.

It is a matter of the utmost importance that the field hospitals, when they are to be established at all, should be got into operation in time to receive the wounded soon after they are injured, and before many have perished or suffered serious impairment of the chances of recovery for want of aid which can only be supplied at some permanent place of rest. The *Surgical History of the War of the Rebellion* records many cases of gunshot fractures and other injuries to soldiers who received the first serious attention only after journeying over long distances, during several days, from the field, sometimes to the general hospitals. Forwarded from place to place for one reason or another, and jolted

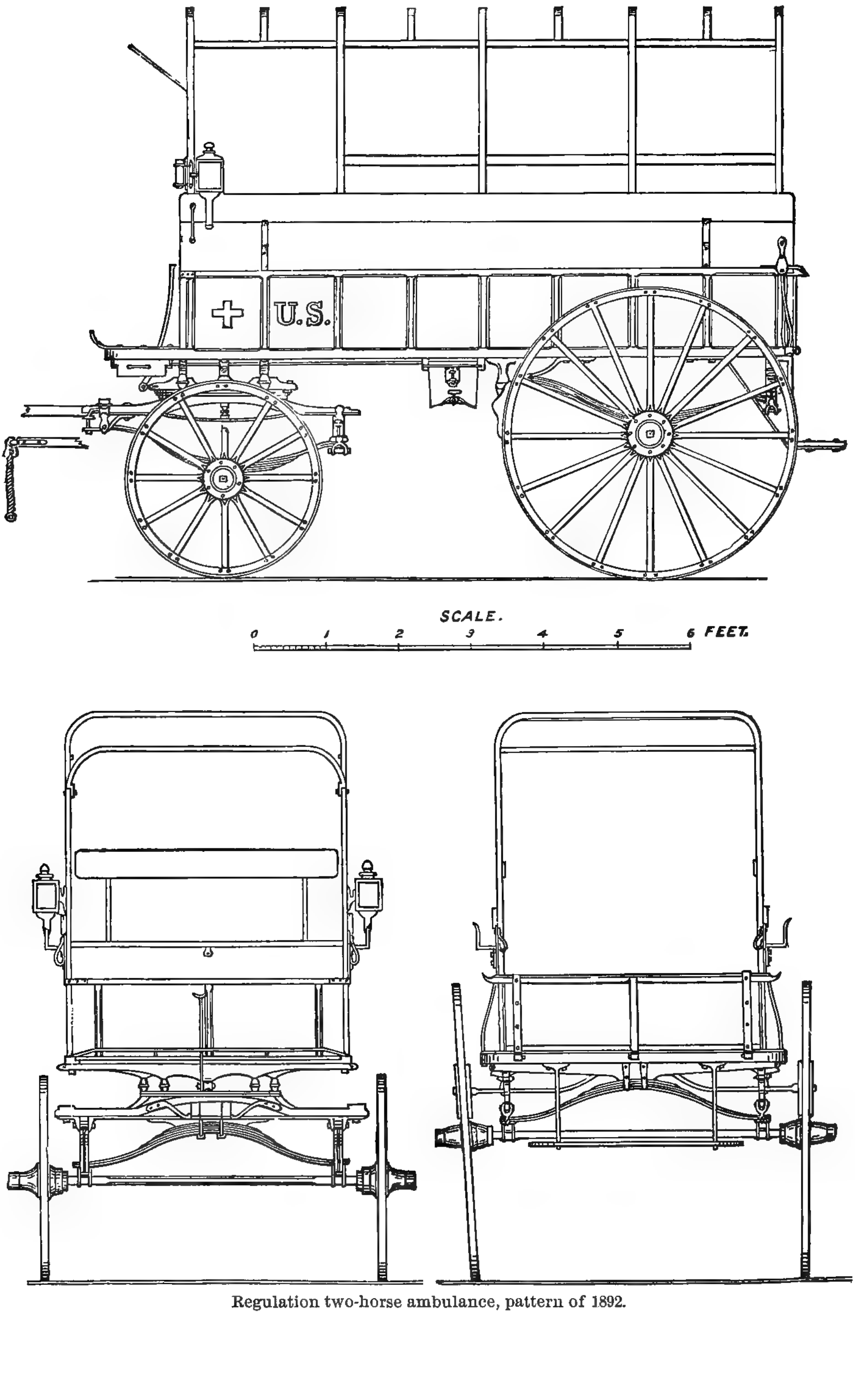
about until their wounds began to suppurate, the treatment which came at last was often too late to save them, and was only followed by the addition of another specimen to the Army Medical Museum, where the ghastly evidence of numerous instances of this kind may be found. It is rarely possible to hurry up the heavy wagons, but the medical staff detailed for hospital duty should come on the field with the troops, and as soon as the engagement becomes settled, or even earlier, they can usually select a site for the field hospital. and with a little assistance begin work at a place where the wounded may be sent, and where they may remain at rest for some time after operations and dressings. In order to carry this plan into effect, it will only be necessary to organize an *advance* or flying *detachment of the field hospital*, consisting of a medicine wagon and one or two light ambulance transport wagons carrying about three tents and three operating tables, with such instruments, dressings, and appliances as will enable the three operating surgeons, their assistants, and a few non-commissioned officers and nurses to begin and carry on their labors while the heavier wagons and material of the train are coming up.

V. Transportation.

The enormous trains of ammunition, provision, and baggage wagons, artillery, ambulances, horses, and mules, that accumulate in the rear of an army form encumbrances to its movements which should be understood and appreciated by those who are preparing supplies to take the field. In 1862, when McClellan's army of about 100,000 men moved back from the Chickahominy to the James River, there were 4000 wagons, 500 ambulances, 350 field-pieces, 50 siege-guns, 40,000 horses and mules, and 2500 head of beef-cattle in its train, "following a single road, a mere woodland path, constantly occupied by troops on the march or obstructed by infantry or cavalry, amid the din of battle, which was heard simultaneously in front and rear and on the flanks."[1] The one object of solicitude was this train, which was kept together in front and closely guarded. No part of it was available for the benefit of sick or wounded except a few light flying ambulances, and many of the more severely injured in all the battles had to be left on the field. The longer the marches undertaken, the farther from railroads and bases of supply, the greater the train of an army becomes and the more difficult it is to handle and protect. The narrow country roads winding through forest and thicket and over streams and hills are beset with ruts and bog-holes which increase in depth with every vehicle that passes. On a dry, sultry day men and animals are enveloped in clouds of dust; when it rains the streams are swollen until every little ditch becomes a formidable obstruction. Wheels sink into the soft ground, wagons break down or stick fast in the mud, their contents are distributed to others already overloaded, mules give out, roads become blocked, trains are delayed, and freight often has to be abandoned or destroyed. The ambulances are crowded, especially if the weather be inclement or there has been much fighting, and numerous sick and wounded straggle along by the wayside. The jolting of wagons, the braying of mules, the sharp cracking of whips,

[1] *Civil War in America*, Compte de Paris.

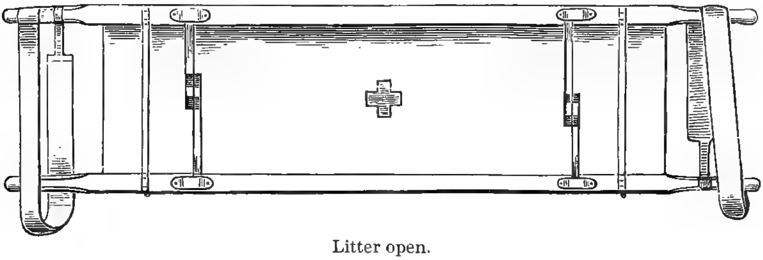
FIG. 261.



Regulation two-horse ambulance, pattern of 1892.

the wild shouts of the drivers characterize the scene, while the sound of distant cannon gives warning that a battle may be near at hand or in progress. The troops farthest to the front are the first to be engaged,

Fig. 262.

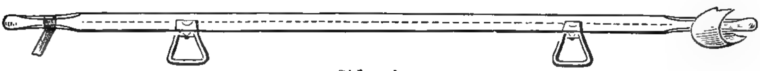


Litter open.

Fig. 263.

Litter partially closed.

Fig. 264.



Side view.

U. S. army regulation hand-litter, 1894. (New pattern under consideration.)

but in the mean time the long train, "winding its way like a huge serpent" over the road, carries with it almost everything provided for the sick and wounded, and may not reach the field until late in the night or not at all.

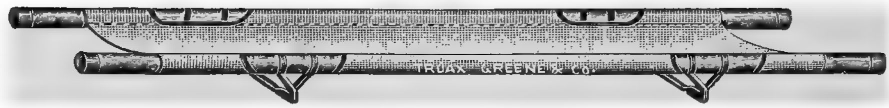
Fig. 265.

The Indian travois as improvised in the field.

The more severe the contest in front and the more doubtful it becomes, the more closely the train is kept together and guarded, and consequently the less available its material is at the very time when it is most wanted.

At the battle of Chancellorsville, Va., May, 1863, the trains, including the ambulances and medicine-wagons, were parked six miles from the field on the opposite bank of the Rappahannock. Later on, authority was given to take a very few ambulances only to the front. Medical supplies brought up in panniers on pack-mules constituted the chief

Fig. 266.



Dr. N. Senn's bamboo-rod stretcher.

resources of the medical department from May 1st to the 5th, when the troops recrossed the river.

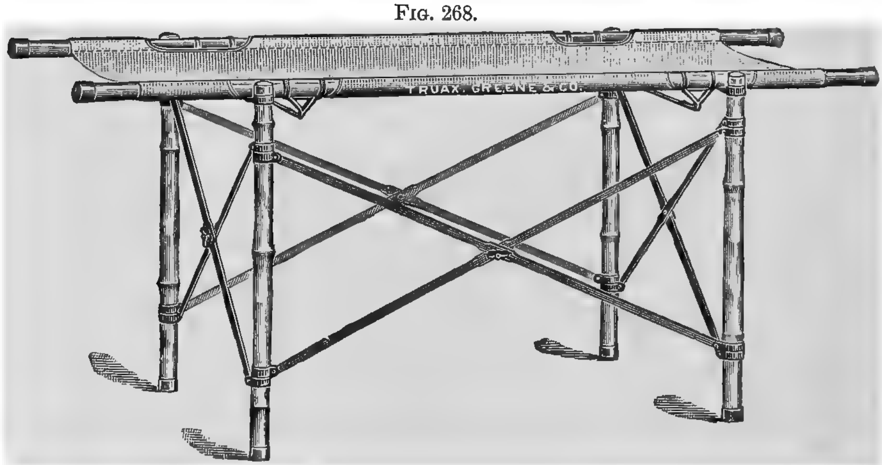
At Gettysburg, on July 1st, the commanding general ordered that all trains except ammunition and ambulance wagons be sent back and parked several miles away. On the 2d, while the battle was in progress, the

Fig. 267.

Dr. N. Senn's stretcher folded for transportation.

trains, including the hospital wagons and the especial train of medical supplies, were sent still farther back to a point about twenty-five miles from the field. In most of the corps the medicine-wagons were taken to the front with the ambulances, and thus some supplies were available for immediate use. Medical Director Letterman in his recollections of

Fig. 268.

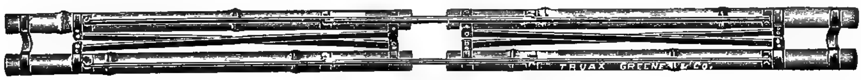


Dr. N. Senn's field operating-table.

the Army of the Potomac says: "The want of tents, cooking apparatus, etc. occasioned by the recent orders was to me, in common with all the medical officers, a cause of the deepest regret and to the wounded of

much unnecessary suffering. Without proper means the medical department can no more take care of the wounded than the army can fight without ammunition. The medical department *had* these means, but military necessity deprived it of a portion of them, and would not permit the remainder to come upon the field. As soon as the battle terminated I requested the commanding general to allow me to order to the hospitals the wagons containing the tents, etc. and the extra supplies. After much persuasion he gave me authority to order half the number of wagons. I at once gave directions to send for them, and also for the remainder as soon as I could obtain permission to do so. These were

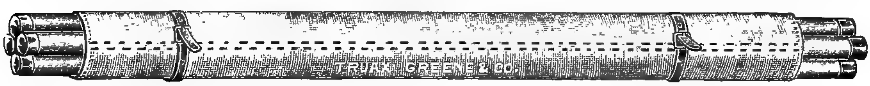
FIG. 269.



Dr. N. Senn's field operating-table when folded.

of much service when they arrived, but they could not reach the field in time to protect the wounded from the drenching rain which fell after the battle." The exposure of the whole field occupied by our troops to the fire of the enemy made it impossible to place the hospitals in rear of their divisions. Most of them were entirely out of the enclosure formed

FIG. 270.



Dr. N. Senn's field operating-table with top or stretcher, the latter wrapped around the folded table.

by the horseshoe-shaped line of battle. Even the temporary halting-places in the rear of the column were so unsafe that they had to be abandoned. Houses and barns, but chiefly the woods, were used as hospitals.

Transport for the sick and wounded generally is ample, and supplies are furnished in abundance, but in time of battle they are seldom to be had when most wanted. In order to get assistance to the wounded with more punctuality and more certainty, as well as more promptly, in future, less dependence must be placed upon the heavy wagons, and some material must be brought to the front on pack-mules and in advance detachments of the field hospitals.

VI. THE ARMY MEDICAL OFFICER AND HIS WORK.

The medical department of modern armies now stands about on a footing with the other staff departments. The independence of the medical corps and the supremacy of its authority in all matters affecting the health of the troops have been at length practically conceded. This concession has come about gradually as the competency of the medical officers improved and the value of their services was more and more appreciated. When they, as a class, were of little or no account, they received little or no consideration. That they now occupy a high posi-

tion in the estimation and confidence of the military authorities is the direct result of their success in organizing and extending the usefulness of the military medical service. The honors conferred upon them are due alike to their own scientific attainments and to the immense improvement in the health, morale, and efficiency which has been wrought among the troops of all nations through their efforts.

In Camp and on the March.—The surgeon is the sanitary officer of his command. Under modern army administration his advice is sought and given in all matters that relate to the physical or mental character of the men, to the location of camps and garrisons, the construction of buildings, ventilation, heating and lighting, quality of food and clothing, cleanliness, and general police and sanitation. The army medical officers have entire charge of the care, feeding, nursing, treatment, and transportation of the sick and wounded. It is their task not only to provide for the wounded on the battle-field, where hundreds and sometimes thousands of men are shot down within a few minutes, but to meet and keep back the enemy in the rear—to protect the troops against attacks of scurvy, diarrhœa, dysentery, and malaria, the invasion of cholera, yellow fever, and typhus, and to ward off numerous other more or less serious troubles which carry on a perpetual skirmishing about every military camp.

In times of peace, in the quietude of garrison life, with comfortable quarters, good food, regular exercise, strict discipline, and proper sanitary surroundings, it is no more difficult to maintain a state of health among soldiers than among citizens of the same locality. The constant care and training to which they are subjected under the supervision of experienced officers; the habits of cleanliness, obedience to orders, and methodical rules; the inspiration of military pride, martial music, and warlike display; wholesome recreation and congenial companionship,—all have an elevating influence on the manhood of a soldier and tend to promote his moral and physical health. But in the field and in camp the conditions are different. Sudden changes in the mode of living, in the kind and quality of food, means of cooking, irregular meals, exposure to the weather, nervous excitement, loss of sleep, defeat and depressing influences, invite and are soon followed by disease in some form, especially among the unseasoned recruits. Macleod says: "It is not the numbers who fall in action that constitute the greatest loss; they are but a small proportion to those who in the course of every campaign sink under neglected wounds, want, fatigue, and disease."

The rapid progress made during recent years in sanitary science and preventive medicine has caused the true value and importance of army hygiene to be appreciated by all classes of military men. Through the advancements in pathology and bacteriology some of the diseases and injuries which most interest the army surgeon are now better understood, and therefore better methods of prevention and treatment have become available. Medical officers everywhere have been prompt to take advantage of this knowledge, and to make practical application of it for the benefit of troops in the field. The favorable results of these measures are shown in the medical and surgical records of recent wars, and of our own campaigns on the frontier, as compared with those of former times.

Sick and wounded, unable to keep up with their commands on the march, are carried on the ambulance train, and those injured or taken ill

during the day are allowed to fall back to it, where at least one medical officer to each brigade is present to receive them and to render such aid as may be practicable until the camping-place is reached, when they are usually quartered with their companies, but, when necessary, the regimental or a part of the brigade or division hospital may be temporarily organized for their benefit. There is usually a morning sick-call, at which the cases requiring ambulance assistance are selected and designated for the march. But the experienced surgeon will soon find that it is much wiser to simply make an informal inspection of such cases as may be presented, extending his aid to the modest and the ambitious, instead of offering a general invitation to men to give up for slight ailments and overcrowd the ambulance train early in the day. One of the most difficult and disagreeable duties of the regimental surgeon is to ride in the rear of the command on a long fatiguing march and keep up the stragglers, deciding promptly and resolutely who *can* continue his exertions and who *must* be allowed to fall out.

On the Battle-field.—Surgery learned in the colleges and witnessed at the hospitals and in the well-appointed and thoroughly equipped operating-rooms, though the same in principle, is quite different in practice from that which is presented at the theatre of war. The conditions and circumstances under which the military surgeons have to perform their work, the peculiar class of injuries to be treated, and the necessarily limited resources available for the purpose are its distinguishing features. The ligation of an artery or the amputation of a limb may be a simple matter where there is ample time and plenty of competent assistants, and where all the necessary means and appliances are at hand to add to the convenience and success of the operation; but when this has to be done on the field with hastily-prepared and deficient arrangements, with inadequate help or none, in the midst of confusion and hurry, and the clamor of wounded men suffering on all sides from want of attention—in the night, most likely, with only the flickering light of a candle or two for illumination—in the rain and mud, with cold hands and benumbed fingers, tired and exhausted from overwork, it is quite another thing.

On the night after a battle the surgeons find no time for rest. They must take advantage of the opportunities offered by darkness and the cessation of hostilities to gather in the wounded and attend to them. These are often widely scattered, and must be sought after in woods, thickets, and fields, and collected together under many difficulties. For two or three consecutive days and nights the demands upon the strength and endurance of the surgeons from these exhausting labors may be almost continuous. The sultry heat and dust of the day are not unfrequently followed by a drenching rain with its unpleasant accompaniments of wet clothes and deep mud. The wounded will be found lying in ravines and on rocky hillsides where the access of ambulance wagons is difficult, or they may be out on the open plain exposed to the enemy's fire, where the least appearance of a light is sufficient to attract a shower of bullets.

On the first line of assistance one medical officer for each regiment remains with his command during the action to give aid and comfort to the wounded and to superintend their collection and removal by the company bearers. Lines of battle sway back and forth or swing round,

and men may fall and lie for hours or days between the two contending forces. Skirmishers and reconnoitering parties advance from time to time in different directions, and thus the injured become separated and sometimes difficult to reach. They must be found and supplied with water and such remedies as may be suitable for the relief of pain, shock, syncope, etc., provided with a diagnosis card, and sent or carried to the rear. The application of dressings is not often practicable under such circumstances. It is of far more importance to hasten the removal of the wounded to a place of greater safety. While one wound is being dressed another may be made.

The identity of the bodies of men killed on the field is often lost. The evidence of this is to be seen in the long rows of tombstones marked "Unknown" in our national cemeteries. To avoid in future the many distressing consequences that arise from this circumstance, every soldier going into battle should be provided with a small metallic tag, and required to wear it about his neck next the skin, bearing his name, company, and regiment and the date and place of his birth.

At the collecting or first-dressing places the dangers are less and the conditions more favorable for offering the wounded some attention. There they are to be divided into three classes and designated accordingly: First, those who are able to walk to the ambulance stations or to the field hospitals; second, those who require transportation; and third, those whose condition or injuries are such that they must remain temporarily where they are. The surgery to be done at the first-dressing places will depend very largely on circumstances. If the hospitals are already established or nearly so, and the ambulance train is in position, then nothing more should be undertaken than just what is necessary to prepare the wounded for their journey to the ambulance station or to the hospital. Attention to the wounds in that case should be limited to such measures as will suffice merely to protect them against infection through the medium of dust, dirt, soiled clothing, or handling, to immobilize broken bones, and to arrest hemorrhage, until the patients can be brought to a place where better preparations have been made for taking care of them.

The fresh surface of wounds should be guarded against the touch of septic instruments or fingers on the battle-field as strenuously as they are on the operating-tables of the best-appointed hospitals. Although it appear that loose fragments of bone are present which may have to be removed from a wound, it is better to let them remain temporarily, lest by disturbing the parts some further extensive interference might become necessary for which the surgeon is not then prepared. They can do no serious harm until the wound comes to be examined under proper antiseptic precautions. Even foreign bodies, such as fragments of clothing, missiles, etc., should not be sought after beyond the surface of the wound for the same reasons.

With a few bichloride tablets, a piece of soap, and some appliance for boiling water the field surgeon can sterilize instruments, clean his hands and the region of wounds, apply dressings, and do minor operations, such as occupy but little time and require but very limited means and assistance. During heavy engagements the wounded often accumulate at the first-dressing places so rapidly that neither time nor material

can be had for elaborate dressings, but as many as practicable of the slighter injuries may be permanently dressed to relieve the labors of those at the ambulance stations and hospitals. In exposing a wound it should be remembered that clothing in the field is very limited, and sometimes very difficult to replace when destroyed. Have the thoughtfulness and consideration to open it along the seams when practicable, so that it may be laid back over the limb or body again when the wound is dressed. The surrounding parts can be quickly scrubbed with soap and water and a 1 : 1000 solution of the bichloride poured over them, washing away at the same time any particles of sand or dirt that may be on the wounded surface, but the protecting clot, if any happen to be present, should not be disturbed.

Some military surgeons then prefer to dust the wounds with iodoform and apply a dressing of dry gauze. The aseptic character of dry dressings is not so reliable in the field as in hospital, where they come direct from the sterilizer. It would be better, perhaps, not to depend too much upon so-called aseptic and antiseptic dressings for field use, but rather make arrangements to boil or otherwise sterilize them on the spot. It will usually be practicable at the first-dressing places to have hot water, to which a few corrosive-sublimate tablets or 1 per cent. of soda may be added if desirable, and to immerse the gauze in this and wring it out. The difficulties and inconveniences of carrying and handling sterile gauze—except in small quantity in sealed tin jars for some special purpose—would thus be avoided. The objections raised by many European surgeons to the first-dressing packages carried by soldiers and attendants might thus be overcome, and the materials contained in them utilized to advantage and with safety.

Dr. Jos. Bogdanik of Biala says on this point: "I would rather wounds were brought to me for treatment which had been exposed for hours to the influences of air and sunshine than those to which, with unclean hands, the sweat-covered materials of these dressing packages had been applied." It will not do to condemn these packages, for with proper precautions they may be turned to good account. Esmarch mentions a number of instances where in the German service they furnished the only material available for dressing wounds during and for some time after battles.

Dressings can only be applied by the surgeons themselves, or by the few hospital corps men who have been trained to assist at operations, and who are reliable and competent to take proper antiseptic precautions. The importance of having a number of hospital-corps men thoroughly trained to assist in this work under the supervision of the surgeons will be apparent. It is said that the fate of a wounded soldier often depends upon the first person who attends to his wounds. The unclean touch of attendants or of so-called surgeons who venture to handle a wound without being thoroughly prepared to do so is more dangerous than the original injury. Dirty fingers and probes in past wars have probably caused more deaths, more cripples, and more agony than the rifle bullet. Ignorance then was a sufficient excuse, but this can never again be pleaded in bar of trial. The one great thing which the new surgery has made possible on the battle-field is the prevention of wound-infection. Every unauthorized person—including the soldier

himself and the company bearers—should be strictly prohibited from touching the wounds under any pretext whatever, and surgeons or their authorized assistants who are found guilty of doing so without proper antiseptic precautions should be promptly punished.

Hemorrhage is often claimed as an excuse for handling wounds. Erroneous ideas seem to prevail in the popular mind as to the danger of hemorrhage after gunshot wounds, and some misleading accounts and very unsurgical recommendations have been given about it even in quite recent literature. The popular apprehension may have arisen from confounding that which is immediately and necessarily fatal on the field and that which comes on secondarily with primary hemorrhage proper among the wounded. Gunshot hemorrhage either does its fatal work at once and under circumstances where surgical aid is impracticable—often in wounds of the head, chest, or abdomen—or it is so slight as to be, usually, of little consequence until the time when secondary or delayed primary hemorrhage may sometimes be apprehended and the patient has already reached the hospital.

Parties interested in the manufacture of tourniquets might be expected to work upon the popular fears for the sale of their patented wares, but it is unfortunate that any respectable medical authority should countenance the general issue of them in opposition to the experience of so many eminent American and foreign military surgeons, who have expressed their belief that primary hemorrhage among the wounded on the battle-field, requiring the application of a tourniquet, is a very rare occurrence. Of 245,790 shot wounds during the War of Rebellion, 110 cases of primary hemorrhage are recorded, probably less than half of which were in the extremities, where a tourniquet could have been applied. Notwithstanding these facts, it has been recommended that every soldier shall provide himself with a stout piece of rubber tubing or a pair of rubber suspenders, which in case of wound in the extremities with any hemorrhage are to be wound around the limb and drawn up tight by the aid of a comrade. If the bleeding still continues (as it often will, for the constriction may be on the wrong side of the wound), one or both openings are to be plugged by thrusting a handkerchief or some such material into them with the finger. In this condition the unfortunate man passes into the hands of others, who will not dare to interfere lest the hemorrhage (which probably never was of the slightest consequence) should be renewed, until finally, after several hours, he reaches the hospital with the limb strangulated, the main vessels contused, the principal nerve-trunk paralyzed and permanently injured, and the wound infected. It is better that one man should perish quietly and painlessly on the battle-field from hemorrhage than that several men should suffer a lingering death from infected wounds in the hospitals.

When, in case of serious hemorrhage, the surgeon is not prepared to tie the vessels at both ends in the wound, the limb may be elevated and a bandage applied from the toes or fingers upward with an aseptic compress on each opening and one over the line of the main artery. Every surgeon should have at hand a good two-inch rubber bandage for use in case of operation, and when a tourniquet becomes necessary this bandage may be used, supplemented by the application of a roller bandage to the

whole limb and an aseptic compress over the wound. The portion of the rubber roller not unwound is tucked under the last turn to make pressure over the main arterial trunk, and urgent attention called to the case on the diagnosis card. When serious internal hemorrhage is going on, a quantity of blood may be saved by constricting one or more of the extremities with the rubber bandage pending operative assistance, but this, like all other applications of the tourniquet, can only be properly done by expert hands.

At the ambulance stations the surgeons are equipped to do formal operations and dressings. As much of this work as practicable is done there to relieve pressure at the hospitals, and as many as possible of the slighter injuries are permanently dressed. The wounded are received, and after careful inspection some are sent to the operating-room, some to have their wounds dressed, and others are held to await the establishment of the hospitals. In European armies the severely and the slightly wounded are separated at this point and sent to different sections of the field hospitals. Hundreds of men with slight injuries may be treated and returned to their commands without leaving the field, whereas if they once get away it is difficult to get them back again.

Among the most important questions likely to arise will be what course to pursue in certain cases of compound fractures. Now that the means of avoiding wound-infection are known, *conservative surgery* will be practised much more than was possible heretofore. Gunshot fractures of the long bones and joints may be treated conservatively when the main trunks of nerves and blood-vessels have sustained no serious injury, when the wound is aseptic, and when the soldier remains with his friends. Even though he should have to wait a day or more and be moved about before finding a place of rest where treatment may begin, if his wounds remain uninfected recovery without amputation or resection may be expected. But when the case has to be left in the hands of the enemy, where neglect and infection are certain to follow, the chances of the sufferer may be more favorable with a good primary stump permanently dressed than with a severe compound fracture which will probably result in suppuration and secondary amputation at the best.

Laparotomy for gunshot wounds of the abdominal viscera, unlike many other operations in military surgery, will always be greatly restricted in its application and usefulness by the very exacting conditions necessary to success. Wounds of the viscera do not admit of delay. There is no way to prevent sepsis, as in external wounds. The time that may elapse before an operation must be done is limited to from three to five hours, after which the chances of success diminish very rapidly. The operation must be done at the hospital in a warm, quiet room protected from wind and dust, with good light, competent assistants, plenty of time, and the advantage of the strictest antiseptic precautions. Very exceptional qualifications are demanded of the surgeon. None but those having skill and especial training in this line, and who have had considerable experience, at least on the cadaver and on living animals, should dare undertake it. The mortality from laparotomy for gunshot wounds of the intestines done by inexperienced operators will be much greater than that under the expectant plan of treatment. Except in siege operations the hospitals will rarely be established in time to offer the benefits of this operation to those

wounded in the early part of an engagement. Very few of the severely wounded will be able to reach the hospital, under ordinary circumstances, within five hours after the receipt of their injuries. Men with penetrating wounds of the abdomen suffer from shock and hemorrhage, and often have to remain for a time on the field, and they usually have to be carried long distances on litters. Such cases are brought to the hospital in the evening or during the night, when the difficulty of operation is increased by the want of proper light, or more frequently not until the following day, when it is too late. An operator with the requisite skill and experience will rarely be available, and where there are many wounded the services of two or three of the best surgeons and an hour or two of precious time can seldom be given to the doubtful benefit of one among a number of men urgently needing assistance. Battles result in defeat just as often as in victory for one side or the other, and among the wounded prisoners the benefit of laparotomy will hardly be realized, although some ante-mortem abdominal sections may be made by well-meaning surgeons with more zeal than discretion. On the whole, the outlook for future operative interference in cases of penetrating wounds of the viscera on the battle-field is not very promising. But still, there will be exceptional cases and especially favorable circumstances where this procedure may become practicable.

After every great battle all the more severely wounded ought to remain and be taken care of as near as possible to where their wounds were received. Instead of being moved from place to place and hauled about on railroad-cars and steamboats for ten days or two weeks to hospitals in the cities already crowded and infected with diseased wounds, tents and temporary hospital accommodations should be promptly brought to the wounded, and they should be left at rest and permanent treatment begun at once. They should be turned over to volunteer aid societies in order to relieve the military surgeons—who must go on with the army—and the best surgeons from civil life should come to attend them. The twenty-one thousand wounded after Gettysburg, and those from other great battles during the War of the Rebellion, included many serious cases that certainly would have done better if they had been treated in tents pitched on frames near the field, where they could have remained for a time, instead of being moved at once to the general hospitals.

DISEASES OF THE BONES.

By NICHOLAS SENN, M. D., LL.D.

The osseous system is an important part of the human body, as it constitutes the framework for the origin and insertion of muscles and furnishes protection for all the vital and important organs, while the long bones form a complicated system of levers for locomotion and prehension. The injuries and diseases of the bones have from time immemorial been regarded as surgical lesions, and their treatment, by common consent, has been assigned exclusively to the surgeon.

Bone affections are prone to extend from one part to another. The progressive involvement of the different tissues by the same disease can be readily explained by the intimate relationship of the nutritive conditions and vascular connections between the different organic constituents of bone. The periosteum, bone, and myeloid tissue receive a common blood-supply, and the venous blood is returned through the same channels. The epiphyseal and articular cartilages receive their nourishment, at least in part, from the adjacent bone. The myeloid tissue is of interest to the physiologist and the physician, as it is now generally conceded that it is one of the blood-producing organs and the seat of serious pathological changes in myelogenous leukæmia. The different anatomic constituents of bone manifest a special predilection for certain conditions of malnutrition and infective lesions.

In osteomalacia quantitative diminution of the earthy salts characterizes the disease, while in fragilitas ossium the reverse is the case. Rickets attacks in preference the bones of the skull and the epiphyseal extremities of the long bones. The virus of syphilis attacks more frequently the periosteum than bone. Acute suppuration begins almost exclusively primarily in the myeloid tissue. Tuberculosis is found most frequently in the epiphyseal extremities of the long bones, and in the short and flat bones, seldom as a primary periosteal affection except in tuberculosis of the ribs. The bone-tissue proper is almost immune to any kind of infection, playing a passive rôle in all acute and chronic inflammations of bone.

To the author has been assigned the task of discussing the affections of bone resulting from malnutrition and infection.

Diseases of the Bones caused by Local or General Malnutrition.

The effects of local malnutrition are familiar to every surgeon, because this condition appears almost constantly as one of the results of chronic joint affections, particularly those of a tubercular character. The atrophy

involves more or less all of the tissues of the affected limb, but is especially well marked in the contiguous bones. The atrophy, osteoporosis, and increased fragility of the bones follow the joint affection in consequence of a combination of causes, the most important of them being inactivity and tropho-neurotic influences.

Serious mistakes have often been made by competent surgeons, in operating for chronic joint affections by resection or amputation, by mistaking the atrophy for an extension of the disease from the joint to the bones, removing, consequently, too much tissue, often substituting an amputation for an intended arthrectomy or resection.

The effect of a general malnutrition, which makes itself manifest by well-marked pathological processes which affect nearly all of the bones of the skeleton, is well shown by rachitis, osteomalacia, and fragilitas ossium, the three diseases of bone caused by defective or faulty nutrition which will now be discussed.

Rachitis.

Rachitis (rhachitis, rickets, English disease) is a disease of infancy and early childhood. Occasionally it appears as a congenital affection (fœtal rickets). Uninfluenced by treatment, it pursues a self-limited course, its duration varying from one to three years.

Etiology.—Rickets manifests a predilection for the time of life noted for the activity of the physiological processes in general, and those of the part affected in particular. The disease is preceded and attended by many life-threatening coincident complications, such as diarrhœa, bronchitis, catarrhal pneumonia, pertussis, rubeola, etc., which, owing to the general debility of the child, are attended by an alarming mortality.

The principal factors in the causation of rachitis are insufficient or improper food, and diseases of the gastro-intestinal canal which impair digestion, absorption, and nutrition. It is most prevalent in large cities, badly-ventilated and over-crowded tenement-houses, and in orphan asylums. From personal observation it seems that it is much more frequent in this country than we have been led to suppose. Very recently four cases of genu valgum of rachitic origin, in children from three to six years of age, were brought at one time to the St. Joseph's Hospital in this city from an orphan asylum in a neighboring city. This number constituted only one of the periodical instalments from the same institution. I have reason to believe that in this country many cases of rickets are not recognized, and the little patients are treated for the complications and not for the original disease. As our cities become larger and more crowded, and the struggle for existence more severe, this disease will become more prevalent, and the surgeons and gynecologists will be made more familiar with its remote consequences. The majority of cases of rachitis are bottle-fed children, and this is the reason why the disease is so common in our orphan asylums. Occasionally the disease develops in children nursing at the breast, but in such cases it will usually be found, upon examination of the milk, that while the quantity may be adequate the quality is defective. In such instances a change to artificial feeding is often followed by a speedy improvement in the rachitic symptoms and in the general health of the

child. We are forced to accept the fact that rachitis is produced by no single cause, but that its true etiology consists in a combination of circumstances and conditions which impair general nutrition at a time of life when the tissues make a special demand on the nutritive resources. It is stated that the intra-uterine form of rachitis has been produced by administration of lactic acid through the mother (Heitzmann).

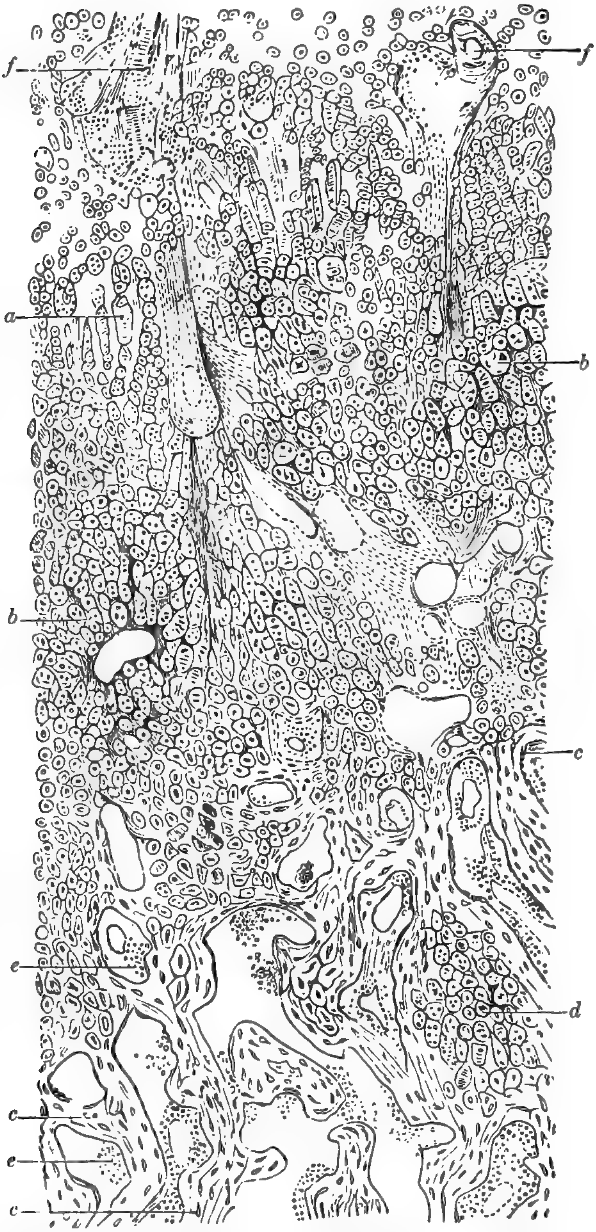
Symptoms and Diagnosis.—If an infant or young child subjected to the influences which we recognize as the most potent etiological factors in the production of rickets presents the general appearance of ill-health, and at the same time manifests a changed disposition, if it is peevish and restless, a careful examination for rickets should be promptly instituted. A more careful inquiry into the clinical history of the case will usually elicit the fact that sleep is disturbed; the child's forehead and scalp are covered by a profuse perspiration, especially during the night; the little patient kicks off the covering during the night; more or less disturbance of digestion accompanies these symptoms. If the disease has existed for some time, as is generally the case when the physician's services are sought, unmistakable evidences of its existence are presented by the characteristic changes which it has produced in certain parts of the skeleton. The bones of the cranium are soft and readily yield to pressure from without (craniotabes). The anterior part of the skull is often found changed in aggravated cases, assuming somewhat of a quadrangular shape. The fontanelles are large, and their closure is often delayed for a long time. At the junction of the ribs with the cartilages an enlargement, something like the provisional callus in a green-stick fracture of the clavicle, is readily detected: these enlargements constitute the so-called "rachitic rosary." The chest is often found flattened from side to side with a corresponding projection of the sternum.

If the child is old enough to sit in an upright position, posterior curvature of the spine is often present, which has been repeatedly mistaken for tubercular spondylitis. Lateral curvature is also often traceable to yielding of the softened bodies of the vertebræ. The most characteristic changes, however, are found in the long bones at a point corresponding to the epiphyseal cartilages. Here the bone is decidedly enlarged and tender on pressure during the active stage of the disease. The unequal development of the condyles of the femur gives rise to an abnormal direction of the articular surface of the femur, resulting either in genu valgum or genu varum, the former being much more frequent than the latter.

The ligaments of joints are relaxed, permitting an abnormal range of motion. Owing to the general softening of the bones the shafts of the long bones yield to muscular traction or the superimposed weight of the body, and bending or even infraction upon slight application of force takes place, resulting often in material shortening of the limbs and permanent deformity. The rachitic pelvis is an object of great interest to every obstetrician.

Prognosis.—The intrinsic tendency of the disease is to recovery in the course of from one to three years. Many children succumb to intercurrent affections. The prognosis is favorable if the disease is recognized in its incipiency and an early rational treatment is instituted. It is astonishing to what extent the deformities caused by rachitis are

FIG. 271.



Longitudinal section of ossifying margin of a long bone in rickets: *a*, proliferating cartilage-cells, the area of proliferation very greatly extended and the arrangement quite irregular; *b*, *b*, calcification of the cartilaginous matrix at different levels, but not followed by formation of medullary cavities. The formation of medullary cavities (*e*, *e*) and of bone is occurring quite irregularly, the level being higher at the right (*c*) than at the left (*c*). At *d* the osteoblasts are forming bone. In various places, especially at *d*, pieces of cartilage are seen in the midst of bone, and an apparent transition of the one into the other is seen. × 90 (Thierfelder).

often corrected spontaneously after the subsidence of the acute symptoms.

Pathology and Morbid Anatomy.—Sections of rachitic bone under the microscope show everywhere errors and defects of ossification (Fig. 271). The most conspicuous feature of the microscopic picture is the enormous exaggeration of the zone of multiplication of the cartilage-cells. Among them we find no definite histological purpose, and no regular arrangement as seen in normal bone-growth. The bone throughout, but especially in the immediate vicinity of the epiphyseal cartilages, is exceedingly vascular. The osteoblasts under the influence of a rich blood-supply secrete masses of osteoid substance, but deposition of earthy salts fails to take place, resulting in osteoid tissue and bone-cartilage without lime salts. This imperfect ossification accounts for the softness and osteoporotic nature of rachitic bone. In a similar manner are the growth and development of the periosteum and perichondral tissue interfered with: we find here also a rich vascular supply and osteoid tissue. The new cancelli of bone do not present a normal arrangement, but are disposed of in an irregular manner, without a definite architectural plan, as is the case in normal growth of bone. Myeloid spaces form in the cartilage, still more increasing the osteoporosis and diminishing the resistance of the bone. That the earthy salts destined to complete the ossification are not thus utilized, but are eliminated through the kidneys, is evident from their presence in large quantities in the urine of rachitic children.

Upon the cessation of the active symptoms, either spontaneously or under appropriate treatment, a change is observed in the tissues of the bone-growing centres. The osteoid tissue is promptly converted into bone tissue by the deposition of the inorganic constituents, and bone is now produced in excess. Osteosclerosis takes the place of osteoporosis. The rachitic bones are heavier than normal bones, their compact layer being abnormally thick and dense. With the process of ossification vascularization is diminished, as well as the myeloid tissue, rendering the bones heavy and exceedingly dense. Excessive ossification of the bones of the face and skull, known heretofore as *leontiasis ossea*, is occasionally observed as one of the results of rickets. Sutton regards leontiasis ossea as a modification of rickets. He reports a case in a young man aged twenty-four. The pathological changes of the skull in this case are shown in Fig. 272.

Treatment.—The general treatment of rachitis consists of the employment of such measures as are calculated to restore normal nutrition. A proper diet and the enforcement of hygienic instructions are the most important part of the general treatment. Pure sterilized milk, eggs, oysters, oatmeal gruel, cracked wheat, raw or rare roast beef, according to the age of the child, are the most appropriate articles of diet. Plenty of sunlight, fresh air, and salt baths will materially hasten recovery. A change of climate will often do more than anything else toward the improvement of the general health, and in obstinate cases should always be recommended. If digestion is impaired, this condition must receive special attention. Contrary to expectation, the administration of lime salts has proved of little avail. The researches of Kassowitz have established the therapeutic value of minute doses of

phosphorus in the treatment of this disease. It should be given in an emulsion of cod-liver oil. Arsenic in small doses has also proved of value. During the acute stage of the disease the patient should not be allowed to sit, stand, or walk, in order to guard against the occurrence

Fig. 272.

Leontiasis ossea.

of deformities. If deformity is found present during this stage, further aggravation can be prevented successfully by an efficient mechanical support. Plaster-of-Paris dressing and plastic splints answer an excellent purpose in such cases.

The treatment of confirmed deformities, after the disease is under control and ossification has taken place, must be in accordance with established rules of orthopædic surgery. Systematic, well-regulated gymnastic exercise is indicated in deformities of the chest. Curvature of the long bones, sufficient in degree to warrant surgical interference, should be treated by osteoclasis. Supra-condyloid linear osteotomy should be resorted to in cases of genu valgum beyond the reach of manual redressement. I have invariably operated on both limbs at the same time, and have never observed any ill results from the operation. The fractures always united promptly by bony callus, without any disturbance in the adjacent knee-joint and without any superabundant amount of callus. A small incision is made through the intermuscular septum over the proposed line of osteotomy, down to the bone, when the soft tissues are retracted, and the section through the bone made with a Macewen chisel

sufficiently far to complete the fracture by manual force. Some care is required in avoiding injury to the popliteal vessels. The little wound is closed by a row of buried and superficial catgut sutures, when the limb is brought into proper position and immobilized in a circular plaster-of-Paris dressing extending from the base of the toes to the groin. Between the limb and the plaster splint a thick layer of antiseptic cotton should be interposed to guard against localized decubitus and harmful circular constrictions. This dressing is not removed for six weeks. At this time the process of repair is nearly completed, and the union is firm enough to render further mechanical support superfluous. Genu varum is corrected by osteoclasis, supra-condyloid linear osteotomy, or a cuneiform osteotomy of the tibia from two to three inches below the knee-joint, according to the degree and location of the curvature.

Osteomalacia.

Osteomalacia (malacosteon, mollities ossium) is a disease affecting the adult skeleton, and, as the different names indicate, characterized by softening of the bones. It differs from rachitis, however, in that it produces softening of normal bone, while the latter prevents temporarily ossification of the soft fœtal bones.

Etiology.—Osteomalacia is met with most frequently in childbearing women, either during pregnancy or lactation. Oppenheimer states that 91 per cent. of cases of this disease are met with in women, 70 per cent. in those pregnant. It is seldom found in the male or the non-puerperal state. Statistics show that it is more prevalent in some sections of a country than others. In Germany, for instance, nearly all cases occurred in the western part. In this country it is exceedingly rare; only a few well-authenticated cases have been reported. In some cases it has been shown to be hereditary. The essential cause is unknown.

Symptoms and Diagnosis.—The actual development of the disease —that is, the bending and fracture of bones—is preceded by certain premonitory symptoms. Failure of the general health and wandering pains in the affected bones, usually attributed to rheumatism, are among the first symptoms to appear. The urine contains a great abundance of phosphate of lime, which, as shown by Mr. Solly, is removed from the bones and eliminated through the kidneys. Another abnormal element of the urine is hydrated deutoxide of albumin, which Dr. Bruce Jones found present in one case in the proportion of 66.97 : 1000. In the pregnant and nursing woman the disease begins in the bones of the pelvis; in the male and in the non-puerperal woman, in the spinal column and bones of the chest. Bending or fracture of the long bones occurs according to the existing pathological conditions. If the softening is limited to the interior of the bones, and only a thin shell of the compacta remains, fracture results. These fractures are produced by the slightest application of force, as lifting the patient out of bed or shifting the position in bed. The fractures in advanced cases are usually multiple. Mr. Tyrrell reports a case with twenty-two fractures, and Mr. Arnott another with thirty-one. If the compacta of the long bones is likewise softened, the bones bend, the limbs become shortened and twisted in all possible shapes. The bones of the head usually remain

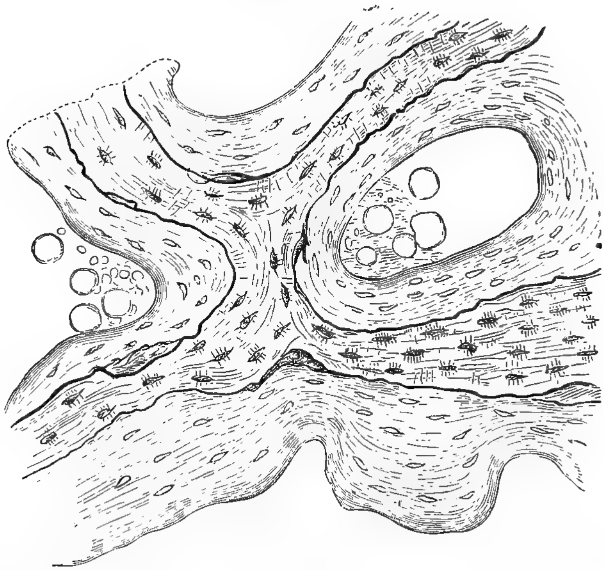
intact—another point of importance in the differential diagnosis between this disease and rachitis.

Rheumatism and malignant disease of the bones are the affections most likely to be mistaken for osteomalacia. Carcinoma and sarcoma seldom involve more than one bone, and in the former the primary tumor in another organ can usually be discovered. The pain in osteomalacia is always referred to the seat of the bone lesions, and not to joints. The exclusion of rheumatism is a matter of no great difficulty. Multiple osteomyelitis is attended by fever, and not infrequently by joint complications.

Prognosis.—In the puerperal form a spontaneous cure has been observed after the expiration of the puerperal period and cessation of lactation. In the non-puerperal form no such favorable change is to be expected. Life is often prolonged for many years, when death finally results from exhaustion. The fractures evince little or no tendency to bony consolidation, and spontaneous correction of the deformities caused by bending of the bones never occurs.

Pathology and Morbid Anatomy.—The essential pathological process in osteomalacia consists in decalcification of the affected bones (Fig. 273). By an unknown chemical process the earthy salts are dissolved,

Fig. 273.



A fragment of bone from a case of osteomalacia. The central part shows the usual appearance of bone, while the marginal parts are transparent, being devoid of lime salts, although still showing bone-corpuscle. × 90.

removed from the parts by the blood-vessels, and eliminated through the kidneys. The solution of the lime salts occurs primarily in the portions of the bone next the medullary spaces and Haversian canals, so that if the bone is examined the central parts of the trabeculæ are seen to be opaque like normal bone, while the peripheral parts are decalcified. The medullary tissue also undergoes alteration; the fatty tissue is replaced by

round-cells. This change in the myeloid tissue undoubtedly accounts for the absence of callus at the seat of fracture.

Treatment.—The general treatment should aim at the removal of the primary cause. In pregnant women it would appear to be justifiable to interrupt gestation. Lactation should be arrested upon the appearance of the first symptoms. Whether the internal use of phosphorus is of any value in arresting the disease has not been sufficiently ascertained by clinical experience. A generous diet and hygienic measures are always indicated. In severe cases the patient should always be placed upon a water-bed and handled with great care. Fractures should be treated upon general principles, and bending of bone prevented by the use of light, comfortable retentive dressings. In three cases Fehling has removed the ovaries, and recommends such operation in the non-pregnant state, and Porro's operation when the uterus is gravid. Fehling's operation has found a number of warm advocates, and has yielded encouraging results. Whether castration in man would exert the same influence in arresting the disease remains to be determined by future experience.

Fragilitas Ossium.

Fragilitas ossium (osteopsathyrosis) is a bone affection in which the pathological conditions are the reverse of those described as characteristic of osteomalacia; that is, the proportion of inorganic to the organic constituents is in favor of the former, rendering the affected bones abnormally brittle. The nutritive disturbance manifests itself by an apparent increase of the earthy salts, with elimination of the cellular elements and diminution of vascularization. The essential cause of this disease is unknown, but many clinical facts point to disturbed or imperfect innervation. The gross appearances of the bones do not indicate any well-marked pathological changes. In a case mentioned by Mr. Stanley "a portion of the recently-fractured femur exhibits a thinning of its walls from the absorption of its inner laminæ, but without softening of its texture; it retains the hardness of healthy bone."

The fragility varies greatly in degree. If the disease is well established and far advanced, fractures occur from the most trivial causes; multiple fractures of the long bones constitute, therefore, the most conspicuous clinical feature of this disease. It affects males and females of different ages. Landerer reports the case of a man twenty-three years of age who had suffered eight fractures, in each instance the fracture being the result of an insignificant injury. Planchard mentions a girl twelve and a half years old who came under his observation who had sustained forty-one fractures. Heredity is acknowledged as one of the etiological factors. An instance is mentioned by Pauli in which, for three generations, certain individuals of a family have suffered from extraordinary fragility of the bones.

Fragilitas ossium has been observed as a complication in some forms of insanity, and as the result of long confinement in bed incident to other chronic ailments. The general health is usually not much impaired unless the disease is associated with antecedent or intercurrent affections.

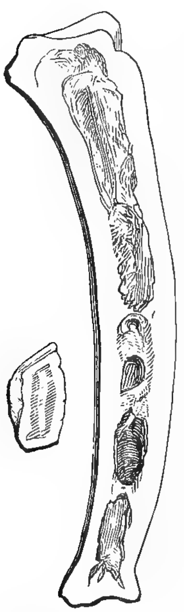
The increased brittleness of bone is not incompatible with prompt and perfect repair of a fracture. In some instances it has been

observed that bony union occurred in a shorter time than under ordinary circumstances. In other cases general nutrition is so much impaired that callus-formation is imperfect or entirely wanting. The usual treatment for fractures should therefore always be instituted in such cases with a view of obtaining bony consolidation of the fracture with the limb in good position. Long confinement in bed should be avoided by the use of plastic circular splints, which will enable the patient within a few days after the accident to avail himself of the benefits of out-door air and exercise. The general health of the patient should be improved by appropriate diet and favorable hygienic and sanitary surroundings. Markoe advises the internal use of iodide of potassium in cases of defective callus-production.

Osteitis Deformans.

This bone affection was first described by Sir James Paget in 1877. The clinical aspects and pathological changes of this form of non-suppurative inflammation of bone are well given in this author's own language: "This form of chronic osteitis begins in middle age or later, is very slow in progress, may continue for several years without influence on the general health, and give no other trouble than those which are due to the changes of shape, size, and direction of the diseased bone. Even when the skull is largely thickened and all the bones exceedingly altered in structure, the mind remains unaffected. The disease affects most frequently the long bones of the lower extremities and the skull, and is usually symmetrical. The bones enlarge and soften, and those bearing weight yield and become unnaturally curved and misshapen, suggesting the proposed name, osteitis deformans (Fig. 274). The spine, whether by yielding to the weight of the overgrown skull or by change in its own structures, may wilt and seem to shorten, with greatly increased dorsal and lumbar curves; the pelvis may become wide; the necks of the femurs may become nearly horizontal. But the limbs, however misshapen, remain strong and fit to support the trunk. In its earlier periods, and sometimes through all its course, the disease is attended with pains in the affected bones—pains widely various in severity and variously described as rheumatic, gouty, or neuralgic—not especially nocturnal or periodical. It is not attended with fever. No characteristic conditions of urine or fæces have been found in it. It is not associated with any constitutional disease, unless it be cancer.

Fig. 274.



Osteitis deformans: sections of tibia and patella.

"The bones examined after death show the consequences of an inflammation, affecting in the skull the whole thickness, in the long bones chiefly the compact structure of their walls, and not only the walls of their shafts, but in a very characteristic manner those of their articular surfaces.

"The changes of structure produced in the earliest periods of the disease have not been observed, but it may be believed that they are inflammatory, for the softening is associated with enlargement, with excessive production of imperfectly developed structures, and with increased blood-supply.

"Whether inflammation, in any degree, continues to the last, or whether, after many years of progress, any reparative changes ensue, after the manner of a so-called consecutive hardening, is uncertain."

This lifelike description of the most important clinical features and gross pathological changes of this disease, given by one of the pioneers of surgical pathology, would indicate that this disease is more closely allied to the class of bone diseases caused by nutritive changes than to inflammatory processes, as they are understood at the present time. The absence of high temperature and other symptoms of inflammation would certainly tend to confirm such an origin. That the disease may remain limited to one or two bones has been shown by a number of clinical observations. Bowlby calls attention to a case lasting ten years, in which, contrary to the rule, but a single bone—the femur—was affected. The patient was a sufferer from gout, and there was associated osteoarthritis of the hip- and knee-joints. Humphrey describes a case in which the bones of the upper limbs were affected, while the bones of the lower extremities showed very little trace of the disease. The disease, like other bone affections caused by faulty nutrition, is sometimes hereditary.

Maguire mentions the fact that one of Paget's original five cases lived to be over seventy years of age, and that two sisters of this patient began to show signs of the same disease. Hutchinson, in speaking of this form of bone disease, says that it is a disease chiefly of senile periods of life; that it may occur in either sex, but is more frequent in men; that it often happens to those who have a gouty family history; that it is probably more common in England than elsewhere; that it consists of a process of osteitis and periostitis, attended by the abundant formation of ill-developed new bone and the breaking to some extent of the old; that it is often in the early stages restricted to one bone; that it tends in all cases to become generalized, involving all the bones of the body; that it has no connection with syphilis, although it may be simulated by it; that it pursues a chronic course.

The **treatment** of Paget's disease of the bones in the absence of any known special cause must be directed mainly toward the improvement of the general health of the patient. As osteitis deformans resembles in many respects rickets, it is possible that the internal administration of small doses of phosphorus or arsenic may prove of value in its treatment.

Exostosis.

Another affection of bone caused by local errors of nutrition is exostosis. By this term is meant a localized hypertrophy of bone to distinguish it from osteoma or bone tumor. Osteomata, or true bone tumors, are most frequently met with in connection with the bones of the cranium and face, while exostosis affects in preference the epiphyseal extremities of the long bones. In these localities the exostosis appears in the form of swellings which spring from the epiphyseal line, and are

composed of cancellated tissue covered by a very thin layer of compact tissue. Virchow applied to this affection the term "enchondrosis ossificans." Favorite localities are the inner surface just above the condyle of the femur, the head of the tibia, or phalanges of the fingers and toes. Mucous bursæ sometimes form on the surface of the swelling, which has given rise to still another name by which such swellings are known—viz. exostosis bursata. According to Rindfleisch, such bursæ are prolongations from the articular synovial membrane. While in some instances such a direct communication exists between bursæ and adjacent joints, in the majority of cases the bursa develops as a new structure on the surface of the swelling, in which event no direct communication exists between it and the adjacent joint. Frequently the surface of such swellings is covered by a thin layer of cartilage. The surface is often very irregular, showing the effect of pressure upon their growth (Fig. 275).

FIG. 275.

Exostosis of head of tibia.

This affection is often multiple. Clark reports a case in which all bones of the body, with the exception of the bones of the skull, were affected. Pick describes a case with 194 exostoses; Leidy, with 126; Lagroux, with 50; Charboux, with 40; and in Campbell's case they are said to have been innumerable. I have observed a case in which both upper ends of the femora were affected to such an extent as to interfere materially with the free motion of the hip-joints.

Many authors regard this form of exostosis as a circumscribed, modified form of rickets in the adult. It appears to be hereditary to a certain extent. Charboux calls attention to a case of transmission of this affection from father to son and from the son to four grandchildren. Maclean describes six cases of multiple cancellous exostoses occurring in the same family. Heredity was manifestly present, but there was nothing to support the idea that the disease was of syphilitic or rheumatic origin or

that it was due to the effects of intermarriage. There were some evidences of rickets. Bessel-Hagen claims that multiple exostoses cause disturbances in the growth of bone. Rubinstein, however, is not inclined to accept the view that a direct relation exists between the size of the exostosis and the decrease in the growth of bones. Schüller believes that the condition is not one of primary retardation of growth, but one of primary overgrowth, in which all growth ceases sooner than under ordinary circumstances. Orlow maintains that exostosis bursata springs from the epiphyseal cartilage, the bursa being of secondary origin. Lagroux agrees with Vix that these exostoses may be the result of exaggerated bone-production incident to a recovery from rickets. Exostosis often results in impairment of function by the swelling interfering with free motion of adjacent joints or the action of important muscles; in other more rare instances the pressure upon important vessels may result in grangrene. Innes reports a case in which exostosis of the head of the tibia (Fig. 5) caused gangrene of the foot and leg by pressing on the arteries. Braun saw apparent complete ankylosis of the hip caused by an exostosis nine inches in length extending downward from the anterior superior spine of the ilium.

Treatment.—As exostosis of the cancellous variety is preceded by a cartilaginous and osteoid stage, it would appear that any therapeutic agent which would favor ossification would exert a tendency to the limitation of the growth. This disease in its active stage almost exclusively affects young adults before ossification has been completed. For these reasons I am inclined to believe that antirachitic remedies, notably phosphorus and arsenic, would prove useful in limiting the growth of the swelling by causing an early transition of immature into mature tissue.

Operative removal is only indicated when the growths interfere with joint-function or produce harmful pressure. In either of these events complete removal must be effected by operative measures. From the fact that these swellings are in very close proximity to joints, and occasionally at least are in communication with them through an overlying bursa, aseptic precautions must be followed out in performing the operation, as otherwise a serious and often life-threatening suppurative arthritis might follow. After free exposure of the base of the swelling it is severed from the shaft of the bone by a chisel. After careful hæmostasis the wound is closed by suturing throughout. Immobilization and absolute rest of the limb must be secured until the wound is healed.

Infective Diseases of the Periosteum and Bone.

The list of infective diseases of the periosteum and bone is constantly growing longer. Some of the affections which I have included among the diseases resulting from abnormal or defective nutrition will undoubtedly soon have to be included under this heading, as their microbic origin will be demonstrated by future observation and research. The inflammatory affections of the bone and its envelope are characterized by certain pathological processes which distinguish them from the diseases caused by malnutrition and regenerative processes. In all inflammatory diseases more or less of the new material is destroyed and lost, while in all reparative processes the new cellular elements are utilized in the formation

of new tissue. In all infective lesions of the bone and its fibrous investment, unless caused by an infection through an open wound communicating with the periosteum or bone, the microbes reach the seat of the disease through the circulation, localize in the part predisposed, and produce there their pathogenic action. The microbes—or, rather, their toxic products—destroy more or less of the exudate which then constitutes the specific pathological product, and the macroscopical appearance of which often furnishes an indication of the character of the microbial invasion. The microbes which are known to be the direct cause of infective diseases of the bone and its envelope, the periosteum, are—1, pus-microbes; 2, bacillus of tuberculosis; 3, unknown microbe of syphilis; 4, actinomyces. The pyogenic microbes produce suppurative lesions, while the remaining microbes, when present in a pathogenic quantity, possess the intrinsic power of converting mature into granulation tissue. The pathological product of the latter, being composed primarily largely of granulation tissue, was termed by Virchow, years ago, "granuloma." The pus-microbes produce an acute suppurative inflammation, while the affections caused by the remaining microbes are clinically characterized by their chronicity.

Periostitis.

Inflammation of the periosteum should be classified according to its microbic cause into—1, suppurative; 2, tubercular; 3, syphilitic; 4, actinomycotic.

Suppurative Periostitis.—Primary suppurative periostitis is an exceedingly rare disease. It usually occurs as a secondary affection in the course of osteomyelitis. Traumatic periostitis, without invasion of pus-microbes, does not occur. The regenerative processes in the periosteum following an injury are constantly being mistaken for inflammation, and are treated upon this wrong supposition. Without microbes there can be no periostitis. A great deal of harm has followed the practice of surgeons who persist in regarding suppurative periostitis as a common primary disease. The treatment adopted upon this ground is not adapted for the primary osteomyelitis which precedes it. Extensive necrosis, serious joint-complications, pyæmia, and death are some of the consequences which follow such a wrong diagnosis and the treatment adopted to meet the indications of a secondary disease in place of the original affection—the osteomyelitis.

In the exceptional cases in which suppurative inflammation of the periosteum occurs as a primary affection the periosteum becomes exceedingly vascular; pus accumulates between it and the underlying bone. The compact layer of the denuded bone is implicated in the infection, and superficial necrosis is a frequent result. Swelling appears almost in the beginning of the disease, while in secondary periostitis it is a later manifestation. Pain and tenderness correspond in extent to the area of infection. Both the local and general symptoms are less intense than in cases of osteomyelitis. Early and free incisions under strict antiseptic precautions will not only promptly remove pain, but will also limit the extension of the disease along the periosteum and adjacent structures.

Periostitis Albuminosa.—Ollier describes a form of acute periostitis

which from the character of the inflammatory product he wished to distinguish from the ordinary suppurative form, and gave it the name *periostitis albuminosa.* Instead of pus, the inflammatory material was of a serous, viscid, or albuminous appearance. Modern writers, however, by more extended clinical observations and careful bacteriological investigations, are inclined to disregard the pathological distinction established by Ollier. Schlange reported four cases of albuminous periostitis in addition to eleven previously observed by different authors. All of the patients were young, between fifteen and twenty years old. There was no pus, but a serous synovia-like fluid with evidences of inflammation in and around the bone. He regards the disease as a form of acute suppurative osteomyelitis, of less intensity than ordinarily seen. Roser regards it as a mistake to create, with Ollier, a new variety of periostitis on account of the presence of a known exudation, inasmuch as he has found such exudation in connection with osteomyelitis and tubercular periostitis, and thinks that the presence in certain cases of serum or bloody serum containing fat-globules is not sufficient to place on a permanent basis the doctrine of a special pathological or etiological form of periostitis, as is claimed by Ollier for the albuminous variety.

Jaksch describes a case of periostitis albuminosa, which the clinical course, as well as the bacteriological investigation, proved to be a modified form of acute osteomyelitis. Schranck collected 32 cases of so-called periostitis albuminosa. In the albuminous exudate were found, on microscopic examination, flocculi of fibrin, and in its meshes white and red blood-corpuscles, globules of fat, nucleated cells, and detritus; also masses of granulation tissue composed of round-cells in varying stages of fatty degeneration. Both layers of periosteum were thickened and œdematous. In both of Schrank's cases pus-corpuscles were present, but in small quantity. In this variety the symptoms are less acute and intense than in the ordinary form of secondary suppurative periostitis following acute osteomyelitis. In one of his cases he had reason to believe that the periostitis was primary. The temperature is rarely very high, and the general disturbance is comparatively mild. It has been observed most frequently in the diaphyses of the long bones, and in preference in the bones of the lower extremities near the epiphyseal cartilages. As compared with ordinary suppurative periostitis, the swelling is at first diffuse; later, more circumscribed. The skin is at first unchanged; later it presents a reddish or bluish discoloration. The disease terminates in a few weeks or it may be prolonged for several years. If necrosis of the bone occurs, the sequestrum is of a greenish color, and the cavity in which it lies is lined with gold-yellow granulations. All the conditions resemble in every respect ordinary suppurative periostitis, only pus is absent. In one case Albert examined the exudate chemically and found mucin. Garrè, Schlange, and Legiehu found in the exudation the staphylococcus pyogenes aureus and made cultivations. Schranck cultivated pus-microbes from the exudate of both of his cases. Vollert believes that in these cases suppuration is present at first, but that the exudate later undergoes a change, caused by degeneration of its histological elements. Schlange regards the disease as a modified form of osteomyelitis. He believes the difference between the exudates is not one in kind, but one of degree. Rosenbach

produced such a form of osteomyelitis artificially in a rabbit. A diminished virulence of the pus-microbes furnishes the most plausible explanation. Suppurative osteomyelitis shows great differences in reference to the virulence of the infection. I have seen numerous cases of osteomyelitis in which later infection of additional bones in the same individual did not give rise to suppuration, the exudate being of a serous or albuminous character, while in other instances the final infection resulted in the production of new bone without loss of tissue, a plastic taking the place of a destructive osteomyelitis.

I have observed several cases of osteomyelitis in which the secondary periostitis answered to Ollier's description of periostitis albuminosa. All of the patients were young persons, and in most of them the posterior surface of the femur was the seat of disease. I fully concur with those authors who regard albuminous periostitis as a secondary periostitis following in the course of a modified mild form of osteomyelitis.

Tubercular Periostitis.—Periosteal tuberculosis of the long bones is a comparatively rare affection, being far less frequent than the syphilitic variety. As a primary disease it involves most frequently the vertebræ, ribs, cranium, and bones of the face. In the last locality it attacks the orbital border of the malar bone most frequently. As a secondary affection in tuberculosis of the long bone it develops most frequently in connection with the diffuse infiltrating form of osteotuberculosis. In tuberculosis of the ribs the disease starts most frequently in the periosteum, and the bone is gradually destroyed from without inward. The compact layer of the ribs at points corresponding to the disease in the periosteum shows, at first, minute circumscribed defects, which gradually enlarge, imparting to the bone a honeycomb appearance. The disease often destroys the continuity of the bone, giving rise to a pathological fracture. It not only spreads in the direction of the bone, but also, by continuity, along the periosteum, terminating frequently only with the destruction of the entire periosteal envelope. The periosteum being the primary starting-point of the disease, extension of the process to the tissues outside of the periosteum is an early occurrence. In this locality the disease is usually a painless affection. The patient often neglects to seek medical advice until he is alarmed by the appearance of a swelling, which upon examination is found to be a tubercular abscess in connection with a tubercular periostitis and osteomyelitis of one or more ribs. In the adult, tubercular spondylitis is most commonly the result of extension of the disease from the periosteum. A number of vertebræ are attacked simultaneously or in rapid succession, and the formation of a tubercular abscess sooner or later must be expected. Curvature of the spine is frequently absent, and when present it is not as angular as when the disease attacks primarily the body of one or more of the bones.

Primary tuberculosis of the periosteum of the cranial bones often leads to extensive necrosis of the external table of the skull, while in primary tuberculosis of the cranial bones the entire thickness of the bones is involved from the beginning. As a secondary disease in tuberculosis of the long bones it is rare, except in the diffuse variety. When the dry, granulating focus reaches the periosteum, a small, soft, elastic, limited granulation swelling forms, first under, later outside of, it. It is characterized by slow growth, comparatively little pain, slight tender-

ness, and a tendency to remain stationary for a long time. If, however, the central focus has become cheesy, and the liquefied, cheesy material comes in contact with the periosteum and paraperiosteal tissues, a tubercular abscess forms in a short time. As soon as the periosteum has been perforated the cheesy material infects the connective tissue, which then takes an active part in the formation of the tubercular abscess. The periosteum ruptures spontaneously; the skin overlying it becomes tubercular, and presents subsequently, at the point of perforation, the appearance of lupus. The bones of the pelvis are occasionally the seat of diffuse primary tuberculosis of the periosteum, which is usually followed by the formation of large tubercular abscesses, which when incised or after spontaneous rupture are followed by mixed infection, profuse suppuration, hectic fever, and often death.

In the differential diagnosis between tubercular and syphilitic periostitis the character of the swelling is of great importance. In the former central softening is of frequent occurrence, and takes place earlier than in the latter; at the same time pain and tenderness are not as well marked as in syphilitic gumma of the periosteum.

Treatment.—The general treatment in tubercular periostitis is the same as in cases in which the same disease is located in other organs—viz. the improvement of the general health by a liberal and nutritious diet, appropriate hygienic measures, change of climate, and the employment of remedies which are known to possess antitubercular properties, notably guaiacol and syrup of iodide of iron. If the periostitis has led to the formation of a subcutaneous abscess, the same should be evacuated by tapping, the débris in its interior washed out by irrigation with a saturated solution of boric acid, after which, according to the age of the patient, from two to eight drachms of 10 per cent. iodoform in glycerin are injected. This little operation should be made under strict aseptic precautions, and repeated every week or two. If the tubercular abscess has been opened intentionally or accidentally, and a fistulous opening has formed, the employment of iodoform injections will no longer prove of value. In such cases the diseased part should be exposed by an incision if accessible to treatment, and all diseased tissue removed by the use of a sharp Volkmann's spoon. It must be remembered that the disease invariably has attacked the underlying bone more or less; hence a thin layer of the osteoporotic bone should be removed with the sharp spoon at the same time. After rendering the cavity thoroughly aseptic, it should be dried and covered with a thin film of finely-powdered iodoform or painted over with a 10 per cent. emulsion of iodoform in glycerin. Packing for a few days with iodoform gauze is preferable to immediate suturing of the wound. The secondary sutures can be introduced at the time of operation and tied upon removal of the iodoform-gauze tampon. In secondary tubercular periostitis the primary bone affection should of course receive prompt and efficient treatment.

Syphilitic Periostitis.—Syphilitic periostitis appears as one of the remote manifestations of syphilitic infection. It belongs to the tertiary stage of syphilis. It is often met with in children as an hereditary affection. It attacks most frequently the bones of the cranium and the shafts of the long bones. A favorite locality is the anterior aspect of the tibiæ. The pain and tenderness are more marked than in tubercular periostitis.

Nocturnal exacerbation of pain is one of the characteristic clinical features of this disease. From a pathological point of view two forms of syphilitic periostitis can be distinguished: 1, ossifying; 2, gumma. In the ossifying variety the granulation tissue is transformed first into osteoid material, and later into bone. The affected bone becomes heavier, the compact layer thickened, and the new bone becomes sclerosed. The gummatous variety appears in the form of swellings of varying density attached to the bone. In some instances the granulations are so soft and pulpy that fluctuation can be distinctly felt on palpation, and such swellings have often been incised under the belief that they were abscesses. If secondary infection with pus-microbes takes place, the granulations break down, an abscess forms, and more or less destruction of the underlying bone is sure to take place.

A careful differential diagnosis between tubercular and syphilitic periostitis is essential before adopting a special form of treatment. If any doubt remains in the mind of the surgeon, the patient should be given the benefit of the doubt by placing him upon active antisyphilitic treatment.

Treatment.—If the disease is recognized in time and subjected to appropriate treatment, the relief is prompt and its further extension is arrested. The most useful therapeutic agent in the treatment of syphilitic periostitis is the potassic iodide, administered, according to the age of the patient, in doses of from five to sixty grains four times a day. It has been my custom to administer a dose an hour before each meal, and the last at bedtime. The drug should be well diluted in distilled water. In obstinate cases it may be combined with small doses of corrosive sublimate. In very urgent and inveterate cases mercurial inunctions should be carried to the point of slight salivation, and followed by the potassic iodide. Operative treatment should only be resorted to in cases in which the gummatous form is complicated by suppurative infection, and after the general treatment has been thoroughly carried out. It is astonishing how speedily large ulcers following syphilitic periostitis granulate and heal as soon as the patient is fully under the influence of constitutional treatment.

Actinomycotic Periostitis.—This variety of periostitis is observed most frequently, if not exclusively, in connection with the jaws as an extension of the actinomycotic process from a diseased alveolus. The inflammatory product consists almost exclusively of granulation tissue, in which the minute yellowish-gray granules, the actinomyces, are imbedded. Like other chronic granulating processes, it is a comparatively painless affection. The granulation tissue is subject to secondary infection with pyogenic microbes, which when it occurs results in the formation of a complicating abscess. The internal administration of potassic iodide has gained some reputation in the treatment of this disease, but the main reliance must be placed on a thorough removal of the infected tissues with the knife, sharp spoon, and actual cautery.

Diffuse Acute Suppurative Osteomyelitis.

Osteomyelitis, medullitis, endosteitis, osteitis, and pseudo-rheumatism (Roser) are terms used to designate inflammation of bone. Acute sup-

purative osteomyelitis is an expression indicating an acute inflammation of the marrow of bone terminating in suppuration. It is an exceedingly frequent affection in children and young adults. As a primary disease it is seldom met with after the skeleton has become fully developed. The traumatic variety was familiar to surgeons before antiseptic surgery was practised. It resulted from direct exposure of the medulla to infective microbes through an open wound, as in compound fractures, gunshot wounds of the bones, resection, and amputation. The so-called spontaneous variety, which will be the principal object in the discussion of this subject here, occurs from the same cause, without direct exposure of the medulla to infective micro-organisms from without.

The traumatic variety has been recognized for a long time by surgeons as a distinct and most serious wound-complication, but the spontaneous form, occurring without an open communicating wound, was not understood until quite recently. We find no mention of this acute affection of bone until 1705, when J. L. Petit gave a description of an acute disease of the long bones which corresponds with what we now understand by osteomyelitis. Similar allusions have been made to it by Gooch, Pott, Cheselden, Hey, and Abernethy, some of their descriptions being sufficiently accurate to enable us to recognize the character of the lesion.

Cruveilhier alludes to the remote consequences of this affection when he says: "The phlebitis of the bones is one of the most frequent causes of visceral abscesses following wounds or surgical operations in which the bones are involved." Nélaton suggested for this disease the term "osteomyelitis" in 1834. In 1849, Stanley gave an accurate account of the spontaneous variety under the title "Suppuration in Bone." In 1855, Chassaignac applied the term "osteomyelitis" for the first time to the spontaneous variety. Among the surgeons who studied the traumatic variety may be mentioned Vallette, Roux, Larrey, Pirogoff, Lidell, Allen, and Otis. Roser, in 1865, on account of the multiplicity of the bone affection and the frequency with which the joints are involved, called the disease "pseudo-rheumatism."

The infectious origin of traumatic osteomyelitis has been recognized for a long time, but the spontaneous form was believed to be purely inflammatory until Luecke first called attention to its infectious character. Demme, Volkmann, Schede, and Hueter have added valuable contributions to the modern literature of non-traumatic acute suppurative osteomyelitis. Pasteur spoke of "furuncle of bone," because he found in osteomyelitic pus a microbe which he claimed was identical with the microbe found in furuncles. The bacteriological researches of Kocher, Rosenbach, Passet, Krause, and Kraske have established the fact that non-traumatic osteomyelitis, like the traumatic form, is a suppurative inflammation of the medullary tissue, caused invariably by infection with pus-microbes.

Primary suppuration in bone begins in the medullary tissue; hence it is not correct to speak of a suppurative ostitis, as is so frequently done by English and American authors. Primary suppurative periostitis is an exceedingly rare affection; consequently, osteomyelitis must be considered as the most frequent of all inflammatory diseases of bone. The medullary tissue of bone in young adults and children is exceedingly susceptible to infection with pyogenic microbes.

Etiology.—The causes of suppurative osteomyelitis in both the acute and chronic form are essential and exciting. The essential cause is the presence in pathogenic quantity of one or more varieties of pus-microbes. Direct extension of a suppurative lesion through the medium of lymphatic vessels—or nerve-sheaths, as Rinne suggests—may be possible, but such a direct connection between a peripheral suppurating focus and a central osseous lesion of a similar nature can seldom be demonstrated. Infection usually takes place by pus-microbes which have found their way into the circulation from a suppurating wound or through the respiratory or intestinal mucous membrane, and which localize in the medullary tissue prepared for their reception and pathogenic action by anatomical peculiarities of the capillary vessels, or by a *locus minoris resistentiæ* created by an injury or antecedent pathological condition. A number of well-authenticated cases have been reported where a subcutaneous fracture became the starting-point of an attack of osteomyelitis in patients who suffered at the same time from a suppurating wound in a part distant and anatomically disconnected from the fracture. In such cases it is reasonable and logical to assume that pus-microbes enter the circulation and are conveyed by the blood-current to the seat of fracture, where they are arrested and find a favorable soil for their reproduction and the exercise of their pathogenic properties.

Such cases are simply the counterpart of what has been accomplished by experimentation. Clinical experience and experimental research have shown that pus-microbes localize in preference near the epiphyseal lines of the long bones. The anatomical peculiarities of the blood-vessels near the epiphyseal lines of the long bones and in the myeloid tissue also present conditions favorable to localization of floating microbes. During the growth of bone the epiphyseal regions are supplied with new, growing, and imperfectly-developed capillary vessels.

Neumann has also called attention to a peculiarity of the capillary vessels in the medullary tissue, their calibre being four times greater than that of the arterial branches that supply them—another important anatomical condition which predisposes to localization of microbes in this tissue.

Histological investigation has likewise shown that the small blood-vessels in the medullary tissue are devoid of a proper vessel-wall, and appear more like channels or excavations than blood-vessels—another condition which must exercise a potent influence in determining mural implantation of infected leucocytes under the action of an exciting cause or causes.

As Luecke has shown, and Rinne again asserts, the medullary tissue is prepared for the action of pus-microbes by the causes which precipitate an attack of some febrile affection, as variola, typhoid fever, scarlatina, rubeola, and diphtheria. Keen has given a good account of the bone lesions which are prone to follow as sequelæ to acute infective diseases. He found 69 cases, of which 22 affected the head, 7 the trunk, 6 the upper and 42 the lower extremities. In 37 cases the disease followed typhoid fever. As to the date of occurrence in 47 cases, 10 were within two weeks, 27 from three to six weeks, and 10 some months after the fever. Keen's explanation was to the effect that the earlier cases prob-

ably resulted from thrombosis, and the later from enfeebled nutrition. Trauma, if any, in these cases was always slight.

Klemm has made some very interesting investigations concerning osteomyelitis as a sequela of typhoid fever, giving at the same time a complete historical account of this complication. Occurring under such circumstances, Chassaignac called the bone disease "typhus des membres." As early as 1835, Maisonneuve called attention to suppurative periostitis as a complication of acute infectious diseases. Freund, in 1885, first drew an accurate clinical picture of inflammatory affection of bone occurring as a complication or sequela of typhoid fever. Fürbringer could find only 5 such cases among 1600 cases of typhoid fever. The bone affection usually appears from one to two weeks after the fever has abated.

The osteomyelitis attacks usually the long bones, in preference those of the lower extremities. Paget and Helferich have studied with special care the clinical course of the bone affection. The swelling is generally circumscribed, the overlying skin discolored, real fluctuation rare. The disease often pursues a chronic course. The inflammatory product is frequently removed by absorption, as sequestration seldom occurs. Among the other terminations must be mentioned caseation and liquefaction. These complications, from a bacteriological aspect, are either the result of infection with the Klebs-Eberth bacillus of typhoid or with pus-microbes which appear in the circulation in consequence of a mixed infection (Schede) caused by the entrance of the microbes into the circulation from a suppurating focus. In the former case suppuration rarely occurs; in the latter instance it is always present and attended more or less by extensive necrosis.

Children and young adults who have passed through an attack of any of the acute infectious diseases are strongly predisposed to an attack of acute suppurative osteomyelitis. Excluding all such influences, there is still left a large number of cases where osteomyelitis attacks persons otherwise apparently in perfect health. My own observations induce me to attribute to exposure to cold an important rôle as an exciting cause. I do not wish it to be understood that exposure to cold alone could ever result in an attack of acute suppuration of the medullary tissue. Pus-microbes inhabit persons in perfect health, and they do not cause disease as long as the circulation remains normal or as long as the tissues are not injured or otherwise prepared for the exercise of their pathogenic activity. If, however, in such persons the circulation in the medullary tissue is disturbed suddenly in consequence of a sudden or prolonged chilling of the surface of the body, congestion, mural implantation, and localization of floating pus-microbes occur in a locality which offers the least resistance in such an emergency, and a suppurative inflammation is established in the myeloid tissue. I have repeatedly observed cases of osteomyelitis in boys who, after active exercise, suddenly became chilled by bathing in cold water, or who, after an exciting game of base-ball, stretched themselves out on the cold ground to rest. A disturbance of the equilibrium of the circulation from any cause is an important factor, in precipitating not only an attack of acute osteomyelitis, but many other local infective processes in persons already infected with the essential cause.

On investigating the clinical history of cases of osteomyelitis we are

often able to ascertain the existence of a suppurating distal focus from which the pus-microbes entered the circulation, producing later the suppurative inflammation in bone under the influence of one or more exciting causes. This observation should teach the profession not to make light of perhaps insignificant suppurative surface affections, as they may become the essential cause of serious complications.

In the relapsing form of the disease the micro-organisms have remained quiescent for some time, and then wake up to new activity. Rosenbach has claimed, and for good reasons, that the pus-microbes in osteomyelitis may remain in a latent condition for twenty years, when, under the influence of provoking influences, they reproduce the disease, although usually in a modified form. It is on this account that usually recurrence takes place in the same bone and in the same part of the bone.

Symptoms.—The clinical picture of a case of acute osteomyelitis is almost characteristic, and, when once seen and carefully studied, can always be recognized. It is only in the gravest form, when the local symptoms are overshadowed by the general symptoms, that a careful observer meets with difficulties in making an early diagnosis. As an early diagnosis is in the interest of the patient as well as the surgeon, all signs and symptoms should be carefully considered to enable the physician to make a prompt and correct diagnosis. Mistakes in diagnosis have often resulted in the loss of valuable time and indefinite postponement of effective therapeutic measures so essential in limiting the extension of the disease and in the prevention of fatal complications.

The disease is usually ushered in by a chill and other symptoms indicative of the commencement of an acute suppurative affection. In grave cases, even during the earliest stages, the general symptoms are out of all proportion to the local lesion, presenting a complexus of symptoms typical of profound septic intoxication. I have observed a number of cases of multiple osteomyelitis where the patients passed into a typhoid condition, with muttering delirium, dry tongue, diarrhœa, and a continued form of fever, with a high temperature and rapid pulse, who died within a week, before the local disease had time to develop marked symptoms of its existence. In such cases the prominent general symptoms are those of a malignant form of progressive sepsis. In some cases of acute osteomyelitis the actual development of the disease is preceded by premonitory symptoms which indicate the route through which infection has probably taken place. A premonitory bronchial catarrh would suggest the possibility that infection had occurred through the mucous membrane of the respiratory organs, while infection through the intestinal canal would give rise to diarrhœa as a preceding symptom. The local symptoms will be considered separately, as a correct early diagnosis can only be made by a careful study of these individually and collectively.

Pain.—Pain is one of the earliest and most constant symptoms of acute osteomyelitis. It may be absent in multiple osteomyelitis, where the patient passes into a condition of stupor almost from the beginning. The pain is described by the patient as being excruciating, of a boring, tearing, or throbbing character. It is not strictly limited to the area involved by the disease, but is often diffuse, extending to the adjacent

joints and over a considerable portion of the shaft. In osteomyelitis of the upper end of the femur it is often referred to the groin and the knee-joint. It is of unusual severity, owing to the tension caused by the inflammatory product in a tissue surrounded by an unyielding case of compact bone. Pain increases in severity as the exudation becomes more abundant, and is diminished or subsides almost completely with the escape of the inflammatory product from the interior of the bone into the surrounding yielding soft tissues. Sudden diminution or cessation of pain is an almost certain indication that perforation of the bone has occurred, and that the pus has escaped into the loose paraperiosteal tissues. The location of the pain should be carefully ascertained, as in multiple osteomyelitis this symptom will indicate, at an early time, the number and location of bones affected. In multiple osteomyelitis the disease may appear simultaneously in several bones far apart, or the disease appears in one bone first, and other bones are attacked later successively. The secondary infections are usually of a milder type, with a corresponding diminution in the severity of this symptom. The appearance of pain in a new locality is generally an indication that another bone has become involved. The severity of the pain in acute cases is often proportionate to the temperature, as it is greatly increased during the night, when the fever reaches the highest point.

Tenderness.—Tenderness is a more valuable diagnostic symptom than spontaneous pain in the early recognition of the disease and in locating the primary suppurating focus. The patient is seldom able to locate accurately the primary starting-point of the pain in an inflamed bone, as the pain is diffuse, but the pain caused by pressure will enable the surgeon to locate the primary focus within the bone with accuracy, even before any external swelling has made its appearance. During the first few days the area of tenderness will correspond to the extent of the disease in the interior of the bone, and the centre of this area will correspond to the primary focus of inflammation. The area of tenderness can be readily mapped out on the surface of the limb by digital pressure, and the centre of this space corresponds to the point of original infection. Tenderness is most acute where the disease has approached nearest the surface of the bone, and by this means the surgeon locates the site for early operation. The tenderness is caused by the secondary periostitis. In osteomyelitis of the long bones pain and tenderness appear first near one of the epiphyses, and extend later toward the shaft of the bone as the deep-seated inflammation and the accompanying periostitis ascend or descend in that direction.

Swelling.—The absence of external swelling during the first few days of an attack of acute osteomyelitis has often given rise to mistakes in diagnosis. As the primary inflammation is located in the interior of a bone, external swelling is absent until the inflammation has extended to the surrounding soft structures, particularly the periosteum and the loose paraperiosteal connective tissue. With the appearance of the secondary periostitis swelling comes on very rapidly, which at first can be felt as a hard induration, soon followed by extensive subcutaneous œdema and deep-seated fluctuation. The rapid local dissemination of the process is largely due to the unyielding nature of the tissues around the primary focus, and to the fact that the blood-vessels are directly

concerned in the extension of the inflammation by the coagulated contents becoming the channels for the diffusion of the septic infection, their contents forming a nutrient medium for the pus-microbes.

Thrombo-phlebitis is a constant and early condition in every case of acute osteomyelitis. The œdema of the soft parts is caused, in part at least, by the deep-seated venous obstruction. The external swelling seldom appears before the end of the first week, but when it once shows itself it increases very rapidly. The swelling usually extends far beyond the limits of the affected bone, very often involving the entire limb. The secondary suppurative periostitis results in extensive denudation of the bone, a large portion of the shaft being surrounded by pus. As soon as the suppurative inflammation extends to the connective tissues the disease resembles very closely deep-seated phlegmonous inflammation; diffuse burrowing of pus takes place between the bone and the periosteum and among the muscles. Within a few days an immense abscess or a very extensive purulent infiltration develops in this manner.

Enlargement of Subcutaneous Veins.—Another evidence of deep-seated venous obstruction is presented by a marked enlargement of the subcutaneous veins. The veins are not only decidedly dilated, but, apparently, have approached nearer the surface of the skin. After tension has been relieved by free incision this temporary varicosity disappears.

Redness.—The skin over the affected bone presents a pale, normal appearance until the pus reaches the subcutaneous tissue, when it presents a red or brownish-red discoloration. The inflammatory blush is usually circumscribed, and indicates the place where spontaneous rupture would occur in the absence of surgical intervention.

Loss of Function.—A limb the seat of acute osteomyelitis is helpless. Suspension of function is one of the conspicuous clinical features of this disease. The limb is as useless as though one of the principal bones had been fractured. The patient is unable to raise it or to move the nearest joint. The limb is not only useless, but the patient will not permit it to be moved, and complains of a sensation as though it would break on its being lifted or otherwise manipulated.

Spontaneous or Pathological Fracture.—If the entire diameter of a long bone is destroyed by the inflammation and the sequestrum becomes partially or completely separated before the involucrum is strong enough to provide the necessary resistance, a spontaneous fracture may occur or the bone will break upon the slightest application of force. This accident does not occur frequently, but when it does happen it is readily recognized and indicates the extent of destruction of bone.

Epiphyseolysis.—Separation of an epiphysis from the diaphysis in the epiphyseal line is of more frequent occurrence than pathological fracture of the shaft. It is another form of pathological fracture which occurs in consequence of necrosis, inflammatory osteoporosis, or molecular disintegration of bone in the epiphyseal line. It is readily recognized by the existence of a false point of motion and the displacements which usually attend fractures in such a locality. Epiphyseolysis seldom occurs before the end of the fourth or sixth week from the beginning of the attack, and is always attended by involvement of the adjacent joint in the inflammatory process.

Synovitis.—Synovitis of joints situated in close proximity to osteomyelitic foci is the rule. The joint affection varies according to the character of the inflammatory product. Catarrhal synovitis appears during the first few weeks, while suppurative synovitis usually occurs later as a complication of acute suppurative osteomyelitis. If the effusion into the joint is of a serous character, it occurs not as a result of infection with pus-microbes, but in consequence of vascular disturbances outside of the limits of the area of infection. The serous effusion appears rapidly and gives rise to pain and contraction of the joint, but, as a rule, disappears spontaneously after the evacuation of the osteomyelitic product.

Suppurative synovitis follows infection of a joint with the same microbes that caused the osteomyelitis, which organisms reach the joint either directly through some pathological defect of the epiphysis or through the lymphatics or blood-vessels. It is possible also that the infection of the joint in some cases is referable to the same source as the bone affection. The occurrence of an attack of suppurative synovitis greatly aggravates the general and local symptoms—much more so than if the effusion is of a non-septic character. If any doubt exists as to the character of the effusion, an exploratory puncture will furnish the necessary diagnostic information.

Diagnosis.—In doubtful and obscure cases a diagnosis should be made by a very careful consideration of the history of the case and a painstaking study of the general and local symptoms. Instead of coming to premature and erroneous conclusions, it is advisable to reason by exclusion and to enter deeply into the subject of differential diagnosis. Mr. Holmes has well said that acute suppurative osteomyelitis is more frequently recognized at post-mortem examinations than at the bedside of the sick. It has often been mistaken and treated for such affections as periostitis, ostitis, inflammation of joints, rheumatism, meningitis, typhoid fever, erysipelas, and even phlegmonous inflammation of soft parts. When we remember that periostitis, ostitis, synovitis, and phlegmonous inflammation are constant secondary lesions, and intimately associated in the clinical history of every case of osteomyelitis, and, furthermore, that the fever attending the latter closely resembles typhoid fever, it is not surprising that mistakes in the early diagnosis of this disease are not infrequent even in the practice of experienced surgeons. A careful consideration of every feature of the clinical picture presented by each case only can enable us to arrive at correct diagnostic conclusions. There is no single pathognomonic symptom that would infallibly lead us to a correct diagnosis.

The fever in acute cases is continuous, with well-marked evening exacerbations, but the difference between the morning and evening temperatures is less marked and typical than in typhoid fever. The pulse is a good indication of the degree of intoxication, as well as the appearance of the tongue. In rapidly fatal cases the pulse is very small and rapid from the beginning, the tongue is dry, and the teeth are covered with sordes. In such cases delirium of a muttering type is also present, and the intoxication of the nervous centres masks the local symptoms, rendering the diagnosis exceedingly difficult. It is always advisable to make careful investigation as to an existing or antecedent

peripheral focus of suppuration, and the possible exposure to some acute infectious disease.

Differential Diagnosis.—I have already insisted that in difficult cases a diagnosis should be made by excluding the affections that have been mistaken for osteomyelitis.

Typhoid Fever.—The acutest and most serious forms of osteomyelitis have been most frequently mistaken for typhoid fever. The prominence of the grave general symptoms and the absence of local signs are responsible for many of the mistakes in diagnosis that have been committed. Goltdammer has reported a typical case of this kind. The general symptoms simulated typhoid fever so closely that the patient, after an illness of ten days, was sent to the medical wards as a severe case of typhoid fever. The pulse ranged between 110 and 120; temperature, 40° to 41° C.; tympanites, dry tongue, enlargement of spleen, bronchitis, rapid respiration, and delirium. On close examination a slight swelling was found over the lower part of the right tibia, with tenderness on pressure—symptoms which finally enabled the attending physician to make a correct diagnosis. During the progress of the case pleuritis, parotitis duplex, and synovitis of the right shoulder-joint made their appearance. The patient died eight days after admission or eighteen days from the beginning of the disease. The necropsy revealed the existence of acute osteomyelitis of the tibia, and pyæmia.

Many such cases have been recorded where the differential diagnosis between acute osteomyelitis and typhoid fever was difficult, if not impossible, until the local symptoms became more prominent. The premonitory symptoms in typhoid fever are more constant and conspicuous than in osteomyelitis. In the latter affection the bronchial or intestinal catarrh which occasionally precedes the attack constitutes the only premonitory symptom, and, as a rule, the disease commences abruptly without any such warnings. A decided chill instead of repeated attacks of chilliness ushers in the disease. Chassaignac believes that diarrhœa is present in almost all cases in the beginning, but this is not in accord with my own observations. The location and character of the pain have already been described. Pain, and especially tenderness, should receive careful attention in the examination of the patient, and these symptoms must be largely relied upon in locating the disease.

Rheumatism.—Acute rheumatism is a polyarticular disease, and the pain and swelling are from the first limited to the affected joints. The general symptoms are not as severe as in grave cases of osteomyelitis. The swelling of the joints comes on much earlier than in the complicating synovitis of osteomyelitis, which seldom appears before the second week.

Phlegmonous Inflammation.—E. von Wahl makes the statement that fluctuation is at first circumscribed in phlegmonous inflammation of the connective tissue, while it is diffuse from the beginning in osteomyelitis. This distinction is a good one. The external swelling in phlegmonous inflammation appears much earlier than in osteomyelitis. The presence of fat-globules in osteomyelitic pus was regarded as diagnostic by Chassaignac and Roser. Fat-globules are often found in osteomyelitic pus, but they are not invariably present, and may also occur in the pus of a phlegmonous inflammation. In osteomyelitis the superficial swelling is at

first œdematous, extends symmetrically around the entire bone, and gradually diminishes at a point where the morbid process in the interior of the bone has become arrested. Phlegmonous inflammation is seldom complicated by synovitis.

Periostitis.—I have repeatedly called attention to the fact that suppurative primary periostitis is an exceedingly rare affection. This disease is enumerated here because so many surgeons still persist in calling the secondary periostitis following osteomyelitis a primary affection. An important element in the differential diagnosis between these two affections is the absence of external swelling in osteomyelitis for the first few days, regardless of the severity of other symptoms; also its rapid diffusion after it has once made its appearance. In periostitis swelling is one of the earliest symptoms. The functional disturbance in periostitis is also less marked than in osteomyelitis.

Erysipelas.—Occasionally osteomyelitis has been mistaken for erysipelas when the disease had reached the connective tissue and produced phlegmonous inflammation. Uncomplicated erysipelas is a dermatitis; the swelling is limited to the skin, and the characteristic discoloration of the skin is present from the beginning, and spreads regardless of regional conditions which limit the extension of osteomyelitis and phlegmonous inflammation.

Prognosis.—The prognosis depends largely on the virulence and extent of the disease. The benefits of early operative treatment must also enter into consideration in judging of the probable final result. Modern aggressive surgery has greatly diminished the mortality of acute osteomyelitis. Under the old expectant, non-antiseptic treatment the death-rate was great. Thus, Demme lost 4 out of 17 cases; Luecke, 11 out of 24; Kocher, 9 out of 26; and Schede, 3 out of 23 cases. Multiple osteomyelitis, with grave symptoms of sepsis from the beginning, almost without exception proves fatal in less than two weeks. Death in such cases is caused by progressive sepsis resulting from the entrance of large quantities of pus-microbes and their toxines into the circulation. If the patient escapes this, the first source of danger to life, he is still exposed during the duration of the acute symptoms to the more remote risks incident to the presence of septic thrombo-phlebitis, which so often becomes the direct cause of a fatal pyæmia. Another fatal accident which may occur is fat-embolism. The medullary tissue is liquefied by the suppurative inflammation, some of the free fat-globules are forced into the circulation by the increased intra-osseous pressure, and death is preceded by the usual symptoms which attend this complication.

The clinical thermometer is an important prognostic aid in this as well as in many other acute infective processes. If the morning and evening temperature remains continuously high—that is to say, ranges between 40° and 40.5° C.—during the first week, it indicates a severe case. The more the general symptoms resemble a severe case of typhoid fever the graver the prognosis. The occurrence of decubitus is always an unfavorable sign. Necrosis of the bone to a greater or less extent is the rule. The extent of periosteal detachment during the acute stage is no indication of the area of subsequent sequestration. Joint affections and partial or complete separation of one or more epiphyses are frequent complications, and add to the danger to life and detract from the func-

tional result. Stiffness, ankylosis, and contracture of joints are events that cannot be avoided in all cases, even by the most skilful and attentive treatment. If the articular cartilages are destroyed by suppurative arthritis, the best result that can be hoped for is a useful but ankylosed joint. Pathological fractures through the shaft of a bone or epiphyseolysis are complications which greatly increase the duties of the attending surgeon, but from which the patients frequently recover with a useful limb.

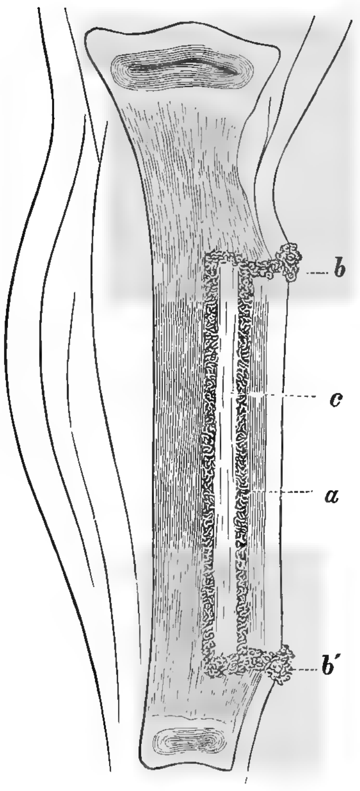
Pathological Anatomy.—The pathology of suppurative osteomyelitis consists in morbid processes which originate in the medullary tissue of bone, and secondarily affect the true bone tissue, the periosteum, and finally the soft tissues outside of the periosteum, followed by regenerative processes in which the periosteum and remaining medullary tissue are most actively engaged if the patient survives the disease. Acute osteomyelitis is essentially a phlegmonous inflammation of the marrow of bone. This disease attacks, preferably, the long bones, although the scapula, clavicle, ribs, and ilium are also frequently affected, especially in cases of multiple osteomyelitis. Of the long bones, the femur is most frequently affected. In this bone the disease manifests a special predilection for the lower epiphyseal region, while in the tibia the order of frequency is reversed. As this disease, without direct exposure of the marrow, is caused by infection with pus-microbes, which reach the tissue through the circulation, the inflammatory process must commence in the capillaries from mural implantation of microbes or leucocytes containing them. Intense alteration of the capillary wall is always present, giving rise to rhexis. The pus almost always presents a reddish appearance, which is owing to the presence of extravasated blood. The inflammation rapidly extends to the larger veins, which become blocked by the formation of a thrombus. If pus-microbes enter the thrombosed veins in sufficient quantity to cause liquefaction of the coagulated blood, pyæmia results from transportation of fragments of such infected thrombi to distant organs. The thrombo-phlebitis is one of the immediate causes of necrosis. The central medullary cavity is rapidly transformed into an abscess-cavity (Plate I.). The pus infiltrates the spongy bone tissue and occupies either the entire medullary cavity, a certain section of it, or is in the form of multiple abscesses. The infection from the central focus extends along the blood-vessels, and soon reaches the periosteum, which becomes the seat of an inflammation which resembles pathologically the primary medullary lesion in every respect. Pus accumulates between the periosteum and bone, causing often very extensive, and occasionally complete, denudation of the underlying bone. At some points the periosteum is destroyed when the pus reaches the surrounding connective tissue, which then becomes the seat of a phlegmonous inflammation. The periosteal defects are not restored subsequently, and at these points openings, called cloacæ, remain in the new bone. After the active symptoms have subsided the suppurative periostitis gives way to a process of repair, during which the periosteum forms a case of new bone around the necrosed portion, which case in technical language is called an involucrum (Fig. 276). The abscess in the soft parts heals, and one or more fistulous communications between the surface of the skin and the dead bone in the interior of the involucrum remain. The external

PLATE I.

OSTEOMYELITIS OF FEMUR.

openings are often quite distant from the cloacæ, and in such cases it is difficult, if not impossible, to discover the dead bone by probing. In cortical necrosis with extensive destruction of the periosteum no involucrum forms, and the sequestrum is later found imbedded in the soft tissues in a cavity lined by granulations. The necrosed bone after its separation is called a sequestrum. If necrosis has occurred at different points, several sequestra will be included by the involucrum. Separation of the sequestrum, like the elimination of necrosed soft tissues, is accom-

Fig. 276.



Necrosis of tibia.

Fig. 277.

Necrosis of entire shaft of tibia.

plished either by suppuration or, what is more common, by granulation. The size of a sequestrum varies from a small spicula of bone to the whole shaft of a bone. Such pieces of bone always show an irregular or dentated outline, which is due either to the original shape of the sequestrum or to the action of the granulations, which diminish the size of the detached bone after its separation. Necrosis is said to be central if the sequestrum is composed of tissue from the interior of the shaft, complete if it represents the entire thickness of the bone, and cortical if it is composed of the external compact layer only (Fig. 277).

In osteomyelitis after amputation, terminating in necrosis, the seques-

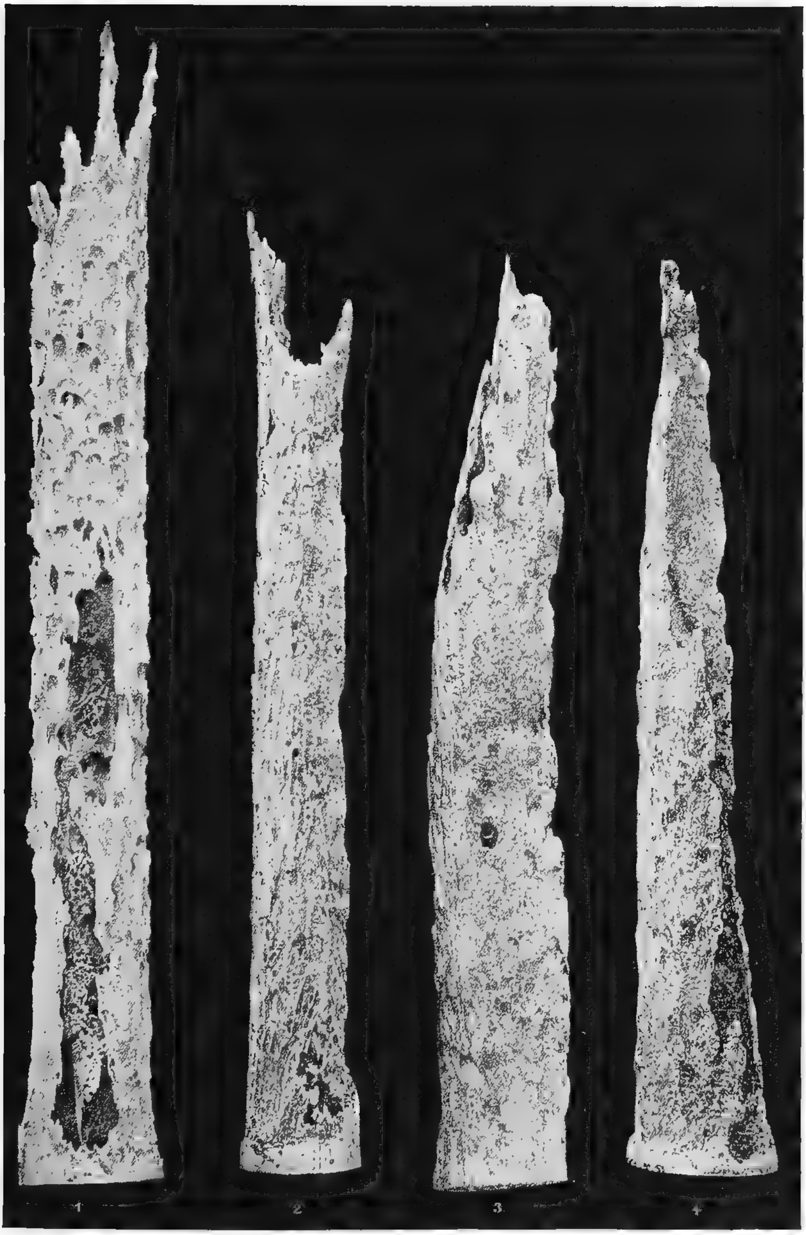
trum usually comprises the entire thickness of the sawn bone and appears tubular in shape (Plate II.).

In complete necrosis a pathological fracture necessarily takes place if separation occur before a firm involucrum has formed. In such cases restoration of the continuity of the bone is effected by the involucrum. Fracture of the involucrum has happened occasionally during a necrotomy or under circumstances which led to fracture of bone. Bending of the involucrum is liable to occur if the patient resumes the use of the limb before ossification has been completed. The medullary canal in the new bone after central or complete necrosis is seldom restored to perfection. The new bone is harder and heavier than normal bone (osteosclerosis), but in exceptional cases it remains porous and soft (osteoporosis)—a condition described by Volkmann and Schede which may become the cause of various degrees of deformity from bending or infraction of the shaft. Separation of the sequestrum will take place in from four weeks to three months, according to the age of the patient and the location and extent of the necrosis.

Treatment.—The prophylactic treatment of osteomyelitis consists in the timely treatment of peripheral accessible suppurative lesions and in avoidance of the usual exciting causes. As the gastro-intestinal canal is undoubtedly more frequently the route through which infection takes place than is generally supposed, and as nature's resources often attempt elimination of the pathogenic micro-organisms in this direction, it would appear rational to administer a brisk cathartic upon the appearance of the first symptoms, as such treatment might prove of great value in arresting further infection from this source. A large dose of calomel, followed by a saline cathartic, would meet this indication most efficiently. Kocher has advised the internal use of salicylate of soda, giving from 6 to 24 grammes in divided doses during twenty-four hours. Salol, beta-naphthol, and the sulphites are valuable intestinal antiseptics. Opium must be given in sufficient doses to alleviate pain. The affected limb should be immobilized from the beginning to prevent joint contractions, and suspended in a slightly elevated position. The use of the ice-bag or cold coil is rational, and often relieves pain. Blistering and the application of iodine do more harm than good. If the cold applications do not prove agreeable to the patient, hot antiseptic fomentations should be tried. In multiple osteomyelitis, with pronounced symptoms of progressive sepsis almost from the beginning of the attack, it is doubtful whether any surgical treatment will have any effect in preventing a fatal termination. In such cases general infection occurs almost from the beginning, and at the necropsy very little, if any, pus is found in the inflamed medullary tissue. The *indicatio vitalis* in these cases calls for the use of stimulants.

Early Operation.—An early operation in the treatment of acute osteomyelitis is one which is performed before secondary suppurative periostitis has appeared, hence before any appreciable swelling has taken place. The operative removal of the infected marrow at this stage of the disease will not only become the means of greatly diminishing the mortality of this disease, but will also prove of the utmost value in limiting its extension—consequently, also, in preventing extensive necrosis. The early removal of the localized product of infection and throm-

PLATE II.



TUBULAR SEQUESTRA FROM AMPUTATION OF THE FEMUR.

bosed veins is the surest prophylactic measure against pyæmia and re-infection from the primary focus. The operation should be done as *soon as a positive diagnosis can be made and under strict antiseptic precautions.* Although operating for a suppurative affection, infection from without must be carefully avoided. The primary location of the disease, usually in the vicinity of an epiphyseal line, is accurately found by searching for the most tender point. This should be done before the patient is placed under the influence of an anæsthetic. Over this point, or as near to it as the nature of the soft parts will permit, an incision is made down to the bone. The operation should be rendered bloodless by the use of Esmarch's constrictor, provided there is but little œdema. After cutting through the skin and fascia the remaining part of the dissection should be made by the use of blunt instruments. When the periosteum is reached, it is incised and reflected with the attached soft parts. The bone is then opened with a small round chisel: in the further steps of the operation ordinary chisels, such as are used by carpenters, answer an excellent purpose. If no pus has formed, the osteomyelitic focus is recognized by the softness and great vascularity of the tissues and the escape of bloody serum. If pus is found, it will probably appear at this early stage as an infiltration. The object of the operation is not only to open the bone, but to remove at the same time all of the infected tissues. The opening in the bone is therefore enlarged in the direction of the shaft to the extent of the disease in its interior. If the suppurative inflammation is extensive, involving half of the bone or perhaps the entire shaft, it is advisable to make several incisions over the bone in the same line, instead of one large incision, thus avoiding a large wound and perhaps injury of important structures; at the same time the interior of the bone is rendered accessible to direct treatment by opening the bone at the corresponding points from which the intervening infected medulla and cancellous bone can be scraped out with a sharp spoon. After the whole cavity has been thoroughly curetted, it is disinfected by irrigating with a solution of corrosive sublimate (1 : 1000), and then dried and mopped out with a 12 per cent. solution of chloride of zinc. Peroxide of hydrogen is also an excellent remedy for disinfecting the cavity. The cavity is then packed with iodoform gauze, which is brought out of the wound or wounds to serve the purposes of a capillary drain. A copious antiseptic dressing is then applied, and the limb immobilized in proper position upon a splint. If on the following day the temperature shows no reduction, the dressings are removed, antiseptic irrigation is again employed, and the limb dressed as before. If, in spite of the early operation and careful antiseptic after-treatment, the suppurative inflammation extends to the periosteum and the connective tissue, the antiseptic occlusive dressing should give way to warm compresses kept saturated with one of the mild antiseptic solutions. Frequent irrigation with a 5 per cent. boric-acid solution, a saturated solution of acetate of aluminum, or a weak æqueous solution of iodine or bromine should be employed.

Intermediate Operation.—An intermediate operation for osteomyelitis is one which is resorted to after the disease has reached the periosteum and connective tissue outside of it; that is, after it has become complicated by phlegmonous inflammation of the soft parts. At this stage

multiple incisions and numerous tubular drains are required to effect complete evacuation and secure free drainage. At this time the affected bone should be opened at different points, which will enable the surgeon to employ intra-osseous antiseptic irrigations. Large openings in the bone under these circumstances might lead to pathological fractures. The subsequent treatment is conducted on the same principles as a case of phlegmonous inflammation and purulent infiltration of the soft parts. Catarrhal synovitis is treated by aspiration, and suppurative synovitis by incision, drainage, and antiseptic irrigations.

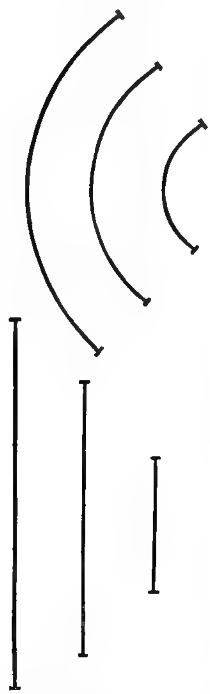
Removal of necrosed bone should be postponed until the sequestrum has separated, and, in the case of the femur and humerus, until the involucrum is strong enough to maintain the normal position of the limb. When the continuity of a bone has been destroyed either by a pathological fracture or the removal of a part or an entire diaphysis, which has separated before the involucrum has become sufficiently firm to serve the purpose of an efficient mechanical support, a suitable splint must be applied for a long time to guard against shortening and bending of the new bone. During the septic acute stage of osteomyelitis with suppurative synovitis amputation may become necessary to save the life of the patient. In exceptional cases the same sad alternative may become a necessity after the acute symptoms have subsided, for the purpose of removing the source of exhaustive suppurative discharges. Should signs of pyæmia arise, our main reliance must be placed on the administration of large doses of quinine and alcohol. As soon as the acute symptoms have subsided, iron, especially tinctura ferri chloridi, should be freely administered.

Late Operation (*Necrotomy*).—Late operations are performed for the purpose of removing the remote results of the inflammation—the necrosed bone and the granulations lining the involucrum. This operation is called necrotomy or sequestrotomy. It consists of the removal by operative interference of the dead detached bone. The removal of dead bone by maceration with dilute mineral acids (Andrews) or by digestion with pepsin and other digestive agents has not yielded satisfactory results. The operative removal of a sequestrum should always be postponed until complete separation has taken place and the involucrum is strong enough to support the limb. Sequestrotomy, if properly performed, is one of the most satisfactory of all operations, as it is attended by little or no danger to life and is usually followed by a favorable result. Its performance has been greatly simplified by the use of anæsthetics and Esmarch's elastic constrictor. As the operation should have for its object not only the removal of the sequestrum, but also the rendering of the bone-cavity aseptic, it should be performed under strict antiseptic precautions. Whenever it is safe to make the incision in the line of one or more fistulous openings, this should be done; but when these are in localities where there would be danger of wounding important vessels, muscles, or nerves, another location from which the bone can be reached safely must be chosen. In operations upon the humerus the exact location of the musculo-spiral nerve must be remembered, and if the incision necessarily comes close to this structure, the deep dissection is made slowly and with the use of blunt instruments until the nerve is found, when it can be held out of the way by the use of a blunt retractor In opera-

tions upon the lower end of the femur, even if the fistulous opening should be in the popliteal space, the incision down to the bone should be made in the course of the intermuscular septum, on the outer or inner side, as the posterior surface of the femur can be reached from either side by making the incision long and by keeping close to the bone, separating the soft tissues well, and keeping them out of the way by the use of retractors. Where the bone is covered by thick layers of muscles the incision is made in the direction of the muscles and at a point corresponding to the intermuscular septum. When the bone is reached the periosteum is incised and reflected with the soft tissues attached to it (Fig. 279).

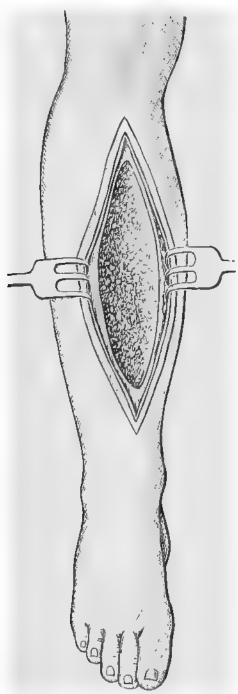
The involucrum is opened by using chisels of different sizes and shapes, as shown in Fig. 278. In old-standing cases the involucrum is as dense as ivory, and the chiseling is an exceedingly slow and laborious process, as only small chips can be removed with each cut of the chisel.

Fig. 278.



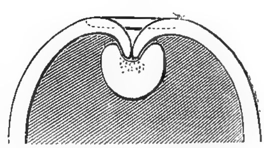
Size and shape of cutting edge of chisels used in sequestrotomy.

Fig. 279.



Cavity in tibia after removal of sequestrum and scraping out of granulations.

Fig. 280.



Neuber's method of treating aseptic bone-cavities.

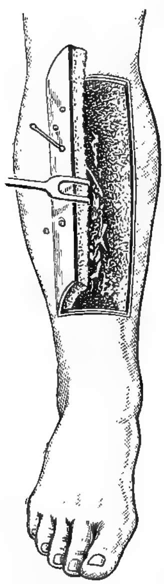
The brittleness of the new bone should warn the surgeon to chisel with care, as otherwise a fracture might result.

Formerly the extraction of the sequestrum ended the operation; at the present time the operation is made to meet another indication—removal of all infected tissue. To accomplish this object it is necessary to expose the interior of the involucrum freely in order to enable the surgeon to remove with a sharp spoon the infected granulations lining it. The bone-cavity after the completion of the operation should present the appearances shown in Fig. 279. The cavity is then rendered aseptic by irrigation with a solution of carbolic acid or corrosive sublimate, when it is dried and lightly dusted with iodoform. For the purpose of securing speedy definitive healing of the wound numerous methods have been suggested. Neuber made flaps of the skin from

each side, which he fastened to the floor of the cavity in the manner shown in Fig. 280.

It has been my experience that necrosis of the flaps is not an infrequent accident after this operation. In other instances the flaps do not attach themselves to the bone surface, and the wound has to heal by a tedious process of granulation. E. Hahn made extensive undermining of the skin on each side for the purpose of obtaining a cutaneous covering for the bone. This operation is open to the same objections. Bier has suggested osteoplastic resection of the involucrum (Fig. 281). Various materials have been used to fill the bone-cavity, either to remain permanently or temporarily. D. J. Hamilton suggested sponge. Schede made use of the aseptic blood-clot. In the clinic at Bonn plaster of Paris has been used, and recently Sonnenburg plugged the cavity with an amalgam, such as is used by dentists in filling teeth. For a number of years I have used chips of decalcified bone in aiding the process of repair in such cases. Kümmell of Germany and Duplay of France have extended this method of treatment, and report equally satisfactory results. Schede's blood-clot is not sufficiently permanent to furnish a satisfactory temporary framework for the granulations during the time required in the treating of a large bone-cavity. The bone-chips when properly prepared are not only aseptic, but antiseptic, and sufficiently durable to serve as a bridgework during the tedious process of repair. The decalcified bone is removed gradually by the granulations springing from the surface of the cavity and the peripheral cover, which in due time are transformed into permanent bone tissue. The more my experience increases with this method of treating aseptic bone-cavities the better are the results.

Fig. 281.



Bier's osteoplastic resection of involucrum.

Essential conditions for success are asepticity of the cavity and the absorbable material employed in filling it. The great advantages of this method of dealing with aseptic bone-cavities are that the external wound heals by primary intention, and that the bone tissue lost by disease and operation is replaced by new tissue. In ideal results the process of repair is so complete that no defect remains at the site of the operation, which is indicated only by a linear scar. After the cavity has been properly prepared, iodoformized decalcified bone-chips are poured into it until this is packed with them to the level of the periosteum. After removal of Esmarch's constrictor blood escapes between the bone-chips and coagulates at once, thus forming a desirable and useful cement-substance which permeates the entire packing, and temporarily glues, as it were, the chips together and the entire mass to the walls of the cavity. The periosteum should be carefully preserved in exposing the bone, and, after implantation, is sutured over the surface of the bone-chips with absorbable aseptic sutures. If the bone is deeply located, it may become necessary to apply a second and third row of buried sutures to bring into accurate contact other overlying soft parts. The skin is finally sutured with silk or silkworm gut. In some instances

it would be undoubtedly superfluous to secure any form of drainage, as, when the cavity is perfectly aseptic and hemorrhage is not in excess of requirements, healing of the entire wound would be accomplished under one dressing. Experience, however, has taught me that tension arising from extravasation of blood often exerts an injurious influence upon the process of healing, and should be carefully avoided. A string of large-sized catgut inserted into the lower angle of the wound answers an excellent purpose as a capillary drain. A copious antiseptic dressing is then applied, the limb immobilized, and placed for at least twelve hours in an elevated position. A limited suppuration is not incompatible with speedy healing of the cavity, as many of the peripheral bone-chips are replaced by granulations, and the remaining space can later be treated in a similar manner by secondary implantation of decalcified bone-chips. This, however, should be postponed until all suppuration has ceased and the cavity has been rendered thoroughly aseptic by appropriate treatment. Bier has recently advocated osteoplastic necrotomy (Fig. 281). With saw, hammer, and chisel the accessible part of the wall of the involucrum is raised with the overlying soft parts in the form of a lid, the sequestrum removed, the cavity rendered aseptic, when the parts temporarily resected are replaced and fastened in their former relative positions with sutures. This method of performing necrotomy is applicable only in exceptional cases, and even when successful the results are not better than those following less severe procedures, and we may therefore anticipate that its sphere of application will be a very limited one.

Circumscribed Chronic Suppurative Osteomyelitis.

This is the bone-abscess of Stanley and the older authors. The etiology of this form of suppurative inflammation is the same as in the diffuse variety, only that the primary microbic cause limits its action to a smaller area. Clinically, two varieties can be distinguished: 1, primary epiphyseal circumscribed osteomyelitis, known as epiphysitis; 2, secondary circumscribed osteomyelitis. The first kind is occasionally met with as a multiple affection, and is then attended by more or less constitutional disturbance, and not infrequently results in epiphyseolysis. The secondary form occurs in the scar-tissue of bones that have been the seat of an attack of diffuse suppurative osteomyelitis, the patient apparently having recovered completely from the primary attack years before. It is still a question under discussion if in these cases the infection is caused by pyogenic microbes which have remained in the tissues in a quiescent state since the primary attack, or whether it is caused by a new infection of the tissues weakened by the first attack. Rosenbach is of the opinion that recurring attacks of osteomyelitis in the same bone are caused by pus-microbes which have remained in the tissues, and which again become pathogenic when the tissues around them are rendered susceptible to their action by subsequent causes. I am strongly inclined to the same opinion. I have seen numerous cases where, in persons from sixteen to twenty-five years of age, repeated attacks of circumscribed osteomyelitis occurred in a bone which during childhood had passed through an attack of acute osteomyelitis. In the relapsing form the disease, with few exceptions, is circumscribed. This would seem to indicate that the action of

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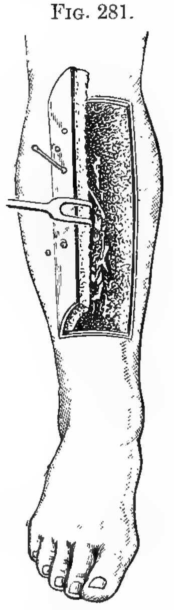
Fig. 281.



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pus-microbes is mitigated during their sojourn in the body, or that the tissues around the infected area are less predisposed to diffusion of the infection.

The tibia, femur, and humerus are the bones which are most frequently attacked by recurrent osteomyelitis. The secondary attacks occur either in the centre of the sclerosed bone, the former site of the infected medullary cavity, or near one of the epiphyseal lines. I have no doubt that secondary osteomyelitis will be of less frequent occurrence after early operations for osteomyelitis as antiseptic sequestrotomy will be more generally practised.

Symptoms.—The local symptoms predominate over the general. Fever is slight or entirely absent, except in cases of multiple epiphysitis. The most important local symptoms are pain and tenderness. The pain is deep-seated, intense, of a boring or gnawing character, and is generally more severe after exposure to cold, active exercise, and during the night. It is often intermittent, and has frequently been wrongly interpreted as neuralgia of bone. The tenderness is circumscribed, and corresponds to the location of the suppurating focus. It is due to a circumscribed secondary plastic periostitis. The external swelling is slight, and often completely wanting. Usually neither redness nor œdema is present.

Syphilitic osteomyelitis is to be distinguished from the suppurative variety by its attacking persons of very different physical conditions, by its tending to form new bone or causing necrosis, by there often being no suppuration induced, by its not involving neighboring articulations, by its frequent occurrence in cranial bones, and by the favorable result that usually follows proper treatment.

Pathological Anatomy.—Limited suppurative osteomyelitis gives rise to a circumscribed abscess, which varies in size from that of a pea to that of a walnut. Necrosis seldom takes place; if it does, the sequestra are small and composed exclusively of cancellated bone. If the abscess is situated in an epiphysis, it may open into the adjacent joint and become the starting-point of a suppurative arthritis (Fig. 282). Thrombo-phlebitis, sepsis, and pyæmia are rare complications. The bone around the cavity is usually thickened and sclerosed. The periostitis which attends chronic suppurations in bone always assumes a plastic type, as the periosteum is beyond the reach of pus-microbes. Epiphyseal osteomyelitis is often associated with chondritis and osteoporosis—conditions which may result in pathological fractures. If in this form of osteomyelitis the suppuration extends to the periosteum, a circumscribed suppurative periostitis occurs, which is followed by the formation of small abscesses in the epiphyseal region. Limited necrosis in these cases is of frequent occurrence. Inflammation of joints often complicates epiphysitis.

Treatment.—Multiple epiphysitis should be treated by early incision and drainage under strict antiseptic precautions. The use of the chisel or trephine may become necessary to expose deep-seated foci. The external incision must be made in such a manner as not to endanger the joint. Early operative treatment is the best-known prophylactic against the occurrence of joint-complications and pathological fracture. In bone-abscesses the inflammatory focus can be located externally with accuracy

by the presence of a circumscribed area of tenderness, and the centre of the tender spot constitutes the guide in the search for the abscess. After the subperiosteal exposure of the bone the chiseling is done in the direction of the centre of the bone by making a track perhaps an inch square.

FIG. 282.

Circumscribed osteomyelitic abscess in lower epiphysis of femur, opening into knee-joint: lining membrane in upper part of cavity detached.

If the abscess is not found at a certain depth, the surrounding tissue is explored with a small drill in different directions until pus is found, when further excavation is again made with the chisel. As soon as the abscess has been fully exposed, the pus is washed out and the size of the cavity ascertained by probing. As the abscess is often surrounded by a zone of tissue infiltrated with pus, all of the infected tissues are scraped out thoroughly with a sharp spoon, after which it is prepared for the implantation of decalcified antiseptic bone-chips in the same manner as in operations for necrosis. These are very favorable cases for this procedure, as the area of infection is limited and the mechanical removal of the infected tissues can be accomplished with a great deal of certainty. I have repeatedly seen cavities the size of a small orange in the head of

the tibia heal under two dressings, with perfect restoration of the bone destroyed by the disease and removed during the operation.

Tubercular Osteomyelitis.

Etiology.—Chronic osteomyelitis of the epiphyseal extremities of the long bones and of the short, and the flat bones, is usually the result of infection with the bacillus of tuberculosis. This view of its essential microbic cause was entertained by a number of leading surgeons long before the bacillus of tuberculosis was discovered by Robert Koch in 1882. What was formerly described as scrofula of bone is now generally recognized as tubercular osteomyelitis. The modern views regarding the etiology of this form of chronic inflammation of bone are based on accurate clinical observations, the results of carefully-conducted experiments on the lower animals, bacteriological investigations, and pathological research. Tuberculosis of bone occurs either as a primary or secondary affection. In the former instance we take it for granted that localization of the bacillus has not taken place in any other organ of the body, and that the tubercular lesion in bone presents itself as an isolated single affection. In the second case the bone affection occurs as a secondary infection from some antecedent tubercular focus. I am inclined to believe that primary infection of bone is an exceedingly rare affection, and König has arrived at the same conclusion on the basis of an enormous clinical experience. The frequency with which pulmonary tuberculosis is met with in cases of bone tuberculosis, and the fact that the lymphatic glands and the thoracic duct are also frequently the seat of tuberculosis, speak in favor of this assumption. The tubercular lesions which give rise to metastatic tuberculosis may be very minute, and elude detection even on making a careful examination on the post-mortem table. Buhl's assertion that in tubercular affections of different organs without an appreciable old tubercular focus this was not absent, but overlooked, may yet receive corroboration by careful research in the future. Schlenker speaks of the frequency with which latent tuberculosis is found at necropsies where non-tubercular affections have caused death. Out of 61 cases without active or manifest tuberculosis he found that post-mortem examination revealed the presence of latent tuberculosis in 27; that is, in 44 per cent. of the total cases. He believes that if the examination had been carried farther by the use of the microscope, the number would have been still greater. The clinical history often points to some antecedent chronic affection of a tubercular nature. In such cases the history is very often something as follows: A patient has passed through an attack of pleuritis, during which he has perhaps expectorated blood, but after a while apparent recovery follows, but the patient has lost flesh and does not gain in weight; at the same time the appetite is impaired. Frequently more or less cough remains; a slight trauma is followed by chronic osteomyelitis, which in its course frequently involves the adjacent joint. Resection is performed. Local recurrence takes place, necessitating finally an amputation, and the patient recovers from the operation, but dies of pulmonary tuberculosis in the course of a few years. This gloomy aspect of bone tuberculosis rests on an extensive clinical experience of surgeons who are certainly

inclined to regard, if possible, the bone affection as a local disease. The patient, and often the medical attendant, usually attribute to trauma an important rôle in the causation of bone-and-joint tuberculosis. The trauma, however, must be regarded at best in the light only of an exciting cause, as no amount of injury can produce the affection without the presence of the essential cause—the microbe of tuberculosis. The trauma only serves as an exciting cause in the production of bone tuberculosis in persons already infected with the bacillus of tuberculosis. The clinical fact remains that bone tuberculosis can be traced only in a small percentage of the cases to a traumatic origin. It is, as Volkmann asserted long ago, characteristic that the injury preceding the development of the disease is always slight, often quite insignificant: tuberculosis of bone, even in tubercular subjects, seldom if ever follows a fracture, as the injury in such cases is productive of such active cell-proliferation that it will hold in abeyance the pathogenic action of the bacilli which might reach the seat of injury with the extravasated blood. In 293 cases of tuberculosis of bone studied by Watson Cheyne, in 188 no definite cause was assigned, while in 105, or 38.8 per cent. of the whole number, the trouble was directly ascribed to the injury.

Tubercular disease of bone is more frequent in males than females, particularly after the first decade, which would indicate that traumatism must be regarded as an exciting cause in a certain percentage of cases. Like suppurative osteomyelitis, tubercular osteomyelitis attacks most frequently young persons and that part of the bones predisposed to the localization of pathogenic microbes, the epiphyseal region of the long bones.

Heredity is an important factor in the causation of bone tuberculosis, as well as of tuberculosis of other organs. Tuberculosis of the bones in the new-born has never been found, but it is well known that it can appear within a few months after birth, and the conditions under which this occurs are familiar. Besides direct transmission of the disease from parents to child, a certain vulnerability of the tissues of congenital origin must be recognized as an indirect cause. In children so predisposed the clinical history often reveals obstinate eczema, blepharitis, ciliaris, glandular enlargements, and other infantile affections of unquestionable tubercular nature preceding the bone affection. Surgeons are well aware of the fact that the existence of an hereditary tendency to tuberculosis adds greatly to the gravity of the disease. The course is usually more rapid, spontaneous cure less likely, and the prospects of a favorable result after operative treatment less favorable than in the acquired form of tuberculosis.

The diseases incident to infancy and childhood, such as pertussis, measles, scarlatina, and diarrhœa, frequently furnish the necessary conditions for the development of osteotuberculosis. In the adult the attack is often preceded by one of the acute infectious diseases, such as typhoid fever, pneumonia, and pleuritis. Pregnancy and lactation are also important etiological factors.

Symptoms and Diagnosis.—The general symptoms are often no indication of the existence or extent of the local disease, as patients with quite extensive bone tuberculosis may present every indication of unimpaired health, and a small osseous focus may produce a rapidly-fatal

miliary tuberculosis. In all cases of suspected bone tuberculosis a careful examination should be made of every organ, in order to discover the primary tubercular dépôt or existing complications. Uncomplicated tuberculosis of bone is essentially a chronic process, and the general symptoms furnish but little information in reference to its inflammatory character. Febrile reaction is slight or entirely absent. A slight rise of temperature toward evening or during the night is very suggestive. Progressive anæmia is always an unfavorable symptom in all forms of so-called local tuberculosis, as it indicates either the presence of additional foci in important organs or accompanies the exhaustive purulent discharges after secondary infection with pus-microbes. The occurrence of mixed infection, with or without a direct infection-atrium, is usually announced by a high temperature and other symptoms of septic infection. Emaciation is present when the disease is far advanced and complicated by abscesses, or when a more important organ is similarly affected.

In incipient cases the local symptoms should be studied with the utmost care, individually and collectively.

Pain.—Pain is an almost constant symptom, but its intensity is subject to great variation. Tension, the most important factor in the production of pain, is a much less marked feature in tubercular than suppurative osteomyelitis. Children suffering from spina ventosa complain of little or no pain, although a whole phalanx of a finger may be almost completely destroyed by a central tubercular osteomyelitis. In rib tuberculosis the pain is either entirely absent or slight. In tuberculosis of the neck of the femur it is often referred to the knee. It is aggravated when the disease invades an adjacent joint. In primary synovial tuberculosis a sudden aggravation of this symptom announces the extension of the disease to the bones. This symptom is promptly relieved in a case of tubercular spondylitis by suspension and fixation, and rest in the recumbent position, and greatly exaggerated by flexion of the spinal column, which inflicts increased pressure upon the bodies of the inflamed vertebræ. The pain is of a dull, aching character, and is intermittent, and more severe during the night. The nocturnal exacerbation of the pain, as evidenced in children by restlessness during sleep, moaning, grinding of teeth, and horrible dreams, is often one of the first symptoms which excite suspicion of the existence of osteotuberculosis.

Tenderness.—While tenderness is an important symptom in detecting and locating suppurative osteomyelitic foci, it is of far greater value as a diagnostic aid in the recognition of osteotuberculosis in its earliest stages. It is caused by a circumscribed periostitis over the tubercular lesion. The existence of an area of tenderness near a joint, corresponding to a tubercular focus in the interior of a bone, is one of the surest indications of the existence of tubercular osteomyelitis. In many cases of epiphyseal tuberculosis patients have been treated for some supposed joint lesion simply because this symptom was not carefully searched for, or, if discovered, its significance was misinterpreted. The existence of a limited area of tenderness in the epiphyseal line and the absence of joint lesions will enable the surgeon to locate accurately a focus in the interior of the bone. In the examination of tubercular joints it is important to search for this symptom over both articular extremities for

the purpose of detecting osseous foci—a matter of great importance, not only from a diagnostic, but also from a therapeutic, point of view.

Swelling.—Mr. Lawrence and, later, Samuel Cooper showed by demonstration of numerous specimens of tubercular joints that the spindle-shaped enlargement is not caused by expansion of the articular extremities, as was formerly supposed, but by swelling of the soft tissues around the joint. With the exception of diffuse tubercular osteomyelitis of the shaft of the long bones swelling is usually absent or slight in osteotuberculosis. External swelling is absent until the atrophic layer of compact bone yields to the intra-osseous pressure—as may be seen in advanced cases of spina ventosa—or until, by pressure-atrophy over the centre of the focus, the compact layer is perforated and a soft, circumscribed, boggy swelling forms underneath the periosteum. The tubercular periostitis which now ensues soon reaches the paraperiosteal tissues, when the swelling increases more rapidly, and is followed by the formation of a tubercular abscess. Such abscesses are prone to migrate in the same manner as tubercular abscess of an articular origin. Œdema is usually not well marked, even if the abscess is large, unless secondary infection with pyogenic microbes has occurred.

Redness.—The skin over a tubercular abscess presents an abnormally pallid appearance until this structure has been reached by the tubercular process, when it becomes red or livid. This discoloration precedes the spontaneous rupture of the abscess underneath it.

Atrophy of Limb.—Atrophy of limb is a constant feature of bone and joint tuberculosis. It is progressive, and appears in a few weeks, certainly in a few months, after the beginning of the attack. It has been attributed to various sources—viz. inactivity, neuritis, vasomotor changes, and reflex influences. It is in all probability the direct result of prolonged non-use of the limb and reflex influences. It affects not only the bone, but every tissue of the limb. Atrophy of the muscles constitutes the most important part of this complication.

Differential Diagnosis.—With few exceptions a chronic inflammation in the epiphyseal extremities of the long bones or in the body of a vertebra is of a tubercular character. In doubtful cases certain diagnostic measures should be resorted to in order to enable the surgeon to make a differential diagnosis.

Akido-peirastik.—Exploration of a doubtful swelling with a short steel needle was introduced by Middeldorpf for the purpose of ascertaining the consistence and probable structure of the tissue composing the swelling. This is an exceedingly valuable diagnostic aid, and, if properly performed, devoid of danger. The puncture is made in the centre of the tender area, and in a direction corresponding to the probable location of the central focus. If the needle meet with any considerable resistance in the bone, it is advanced by rotary movements: the arrival of its point in the granulating centre or caseous focus is announced by a sudden loss of resistance. By advancing the needle sufficiently to touch with the point the opposite side of the cavity its probable size and exact location can be ascertained.

Inoculation Experiments.—In cases of great doubt little fragments of granulation tissue or a few drops of the liquefied material can be removed from the inflamed area with an exploring syringe, and with

the material removed a guinea-pig or rabbit can be inoculated. If it is a case of tuberculosis, the disease will be reproduced in the animal. The result of the experiment thus furnishes the final proof of the nature of the affection.

Probing.—This diagnostic resource should not be employed indiscriminately in the exploration of fistulous tracts, as the careless use of the probe has resulted in a great deal of harm by causing infection with pus-microbes and by aggravating the tubercular lesion. The danger attending the use of this instrument can be greatly diminished by a recourse to adequate antiseptic precautions. Cauterization of the granulating surface with nitrate of silver previously to or simultaneously with the use of the probe, by coating it with the melted salt, is another efficient prophylactic measure. The affections which are liable to be mistaken for tubercular osteomyelitis, and *vice versâ*, are—synovial tuberculosis, sarcoma, echinococcus, epiphyseal multiple osteomyelitis, chronic osteomyelitis, and syphilitic affections of bone. A careful study of the clinical characteristics of these affections, combined with a careful consideration of the signs and symptoms present, will enable the practitioner to arrive at correct diagnostic conclusions. In cases of doubt in the differential diagnosis between tubercular osteomyelitis and syphilitic bone affections, in which the results of treatment do not furnish positive diagnostic information, it may become necessary to resort to inoculation experiments in making a final diagnosis.

Prognosis.—Spontaneous healing of a tubercular focus in bone is possible under favorable conditions. If the patient is well nourished, and, above all, if the blood is in a normal condition, limitation of the disease may occur before caseation has taken place, and if cheesy material has formed and can be removed by operative interference, the prospects of a permanent recovery are good. It must be, however, admitted that every person who has suffered from an attack of osteotuberculosis during childhood or youth, even if an apparent perfect cure has been effected spontaneously or by operative measures, is always in danger of becoming the subject of re-infection from the primary or osseous focus at any subsequent time. Healing by cicatrization frequently takes place in the small, dry granulating foci so long as the coagulation necrosis is limited and no caseation has occurred. If caseation has taken place, and the cheesy material has not undergone liquefaction, encapsulation of the tubercular product can take place by the wall of granulation tissue lining the cavity becoming converted into cicatricial tissue, forming a capsule, which, for the time being at least, mechanically prevents the local extension of the disease. Small sequestra may become imbedded in a connective-tissue capsule in a similar manner. A large sequestrum cannot be similarly disposed of, but must be eliminated either spontaneously or removed by operation before healing can be accomplished. If the disease invades the adjacent joint, the prognosis is more grave, and the chances of a spontaneous recovery are much lessened.

The prognosis is always more serious, other things being equal, if the bone affected is so located that elimination of the tubercular product is rendered difficult, and the removal of the primary focus by operative treatment is anatomically impossible. The danger to life is increased if a large tubercular abscess has become infected with pus-microbes, as the

secondary infection results in destruction of the granulation tissue lining the cavity—a condition which favors the local and general extension of the tubercular infection, and at the same time brings sepsis, exhaustion from profuse suppuration, and amyloid degeneration of important internal organs as additional elements of danger.

The prognosis is always more unfavorable in persons advanced in years than in children, as limitation of the disease occurs more frequently in the latter. Re-infection from an osseous focus is of frequent occurrence, leading to pulmonary or some other form of visceral tuberculosis or general diffuse miliary tuberculosis. Secondary glandular tuberculosis is of rare occurrence.

The duration of the disease is an important element from a prognostic view. Multiplicity of the affection augments the danger to life and retards a spontaneous cure. König has observed miliary tuberculosis following primary osteotuberculosis only sixteen times out of thousands of cases that have come under his personal notice. In all of these cases the general tuberculosis followed operations for tubercular lesions. Diffuse miliary tuberculosis may and does occur without such an exciting cause. I have observed tubercular meningitis develop in young children on several occasions in the course of tubercular coxitis without operative intervention, which shows that a tubercular focus in bone, undisturbed by operation, may become the distributing-point of bacilli, and constitute the immediate cause of metastatic tuberculosis in another organ, or general miliary tuberculosis.

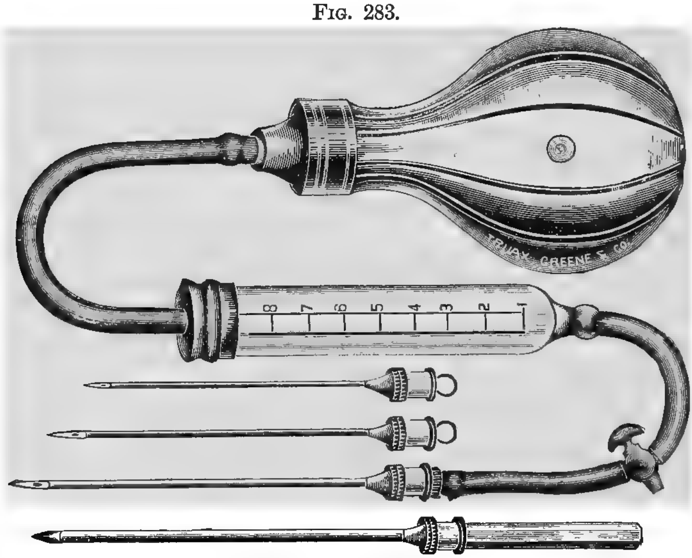
Treatment.—Early effective treatment is of paramount importance, because the intrinsic tendency of the disease is toward progressive extension, and if left to itself sooner or later the appearance of serious complications is the rule, spontaneous recovery the exception.

The general treatment must be tonic and supporting. Dietetic and hygienic measures are of more importance and value than the administration of drugs. Sea-bathing and change of climate will often accomplish more than bitter tonics, iron, quinine, arsenic, and cod-liver oil. A combination of potassic iodide with the syrup of iodide of iron has, in my experience, produced better results than any other method of medication. Guaiacol is another valuable remedy, but in order to render it effective its use must be continued for six months to a year. I usually administer it in milk before meals and at bedtime in doses of four to five drops for an adult. If it disturbs digestion, the dose should be diminished or its use temporarily discontinued. Children suffering from osteotuberculosis should be carefully dressed; flannel under-garments must be worn constantly, except during the hot summer months, when their place can be taken by silk or cotton under-clothing. Sudden chilling of the surface is always detrimental, and should be carefully guarded against. Out-door air and a certain amount of exercise should be procured whenever the local disease does not furnish a positive contraindication. Tepid salt-water baths are of great value in such cases, as they stimulate the peripheral circulation, and in so doing prevent internal congestion. An intelligent general treatment should go hand in hand with the use of appropriate local measures: it is only by such combined treatment that a favorable impression is made upon the disease.

A few of the more important local agencies will now be discussed.

Rest.—The importance of enforced and absolute rest cannot be overestimated. Hilton, Chiene, and others have brought this important element of treatment forcibly to the attention of the profession. In securing rest for the diseased part as nearly as can be done by position and the use of mechanical measures, the process of repair is favored and further extension of the disease arrested or limited. The most efficient way to procure rest, not only for the affected part, but for the entire body, is to confine the patient to bed; but, as these affections are noted for their chronicity, lasting for months and years, enforced rest by this method would seriously impair the general health, and the benefit derived from it for the local lesion would be more than overbalanced by the lack of fresh air and out-door exercise; and on this account it is advisable, in the majority of cases, to resort to one of the numerous mechanical appliances which will immobilize the part, while at the same time the patient can avail himself of the benefits to be gained by out-door air and change of scenery and surroundings. In tubercular spondylitis suspension upon a Rauchfuss sling, with or without head-extension, and later fixation of the spine in extension in Sayre's plaster-of-Paris jacket, will meet this indication to perfection. In tuberculosis of the epiphyseal extremities of the long bones immobilization of the limb in a circular plaster-of-Paris dressing will not only secure the most perfect degree of rest, but will at the same time prevent contractures and partial or complete pathological dislocation of the articular extremities. Rest should be continued until

FIG. 283.



Senn's exploring and injecting syringe.

all active symptoms disappear. Rest, like all other valuable therapeutic agents, if continued too long will prove harmful; hence the indications for its abandonment should be thoroughly and frequently searched for from time to time.

Parenchymatous Injections.—The direct application of well-known

antibacillary agents to the diseased infected tissues constitutes an important part of the treatment. The instrument to be employed for this purpose is an ordinary Pravaz syringe with an asbestos piston. The instrument is to be sterilized by boiling before using it. I have recently devised a syringe for making intra-articular and parenchymatous injections, which is shown in Fig. 283, and which I now use exclusively for this purpose. The remedies which have proved most successful are a 10 per cent. emulsion of iodoform in glycerin, an emulsion of balsam of Peru of the same strength, and a 1 per cent. solution of trichloride of iodine. The bone is perforated with the largest needle of the syringe in the centre of the tender area, and after the focus has been reached the injection is made very slowly, in order to bring the emulsion or solution in contact with as large an area of infected tissue as possible. The injection is to be repeated every week or two.

Ignipuncture.—This therapeutic resource in the treatment of bone-and-joint tuberculosis was introduced by Richet in 1870. The operation is now performed exclusively with the needle-point of a Paquelin cautery heated to a white heat. The site of puncture, corresponding to the centre of the tender area, is rendered aseptic in the usual way. As soon as the surface of the bone is reached the point is advanced by rotatory movements. The instrument is withdrawn from time to time, and heated before reinserting it to prevent impaction in the canal. The entrance of the point into the focus is announced by a sudden loss or diminution of resistance. If the focus is large, punctures can be made in different directions through the same external opening. The channel thus made is dusted with iodoform and an antiseptic dressing applied. The first effect of the operation is diminution or cessation of pain. In the course of two or three weeks the tubular eschar is removed and the canal filled with granulations. The cauterization of a deep-seated tubercular focus in such a manner destroys a part of the tubercular product and stimulates the surrounding tissues to an increased tissue-proliferations: it becomes the direct means of substituting for the tubercular osteomyelitis a plastic osteomyelitis. From my own experience I regard this procedure as a potent agent in the treatment of accessible foci of uncomplicated bone tuberculosis. It is most useful in the early treatment of tarsal, carpal, and epiphyseal tuberculosis.

Operative Removal of Tubercular Foci.—The operative removal of a tubercular focus in the epiphyseal extremity of a long bone with chisel and sharp spoon must be regarded as a curative and prophylactic operation. It is intended to effect mechanical removal of the tubercular product, which in itself will prevent invasion of the adjacent joint. As such foci are usually near a joint, great care must be exercised not to open the joint. The external incision must be carefully planned, and the bone exposed by reflecting the periosteum. After the focus has been fully exposed with the chisel, the tubercular product and surrounding osteoporotic bone are removed with a sharp spoon. After thorough cleansing and iodoformization of the cavity, the latter is filled by decalcified iodoformized bone-chips in the manner previously described. The periosteum is sutured separately, and over it the parts are approximated in the usual manner. Capillary drainage with a bundle of catgut is

usually indicated. An antiseptic dressing and a fixation splint complete the operation.

Resection.—Resection may become necessary after the osseous focus has reached the adjacent joint. The operation should consist of a thorough extirpation of the diseased synovial membrane and capsule and the removal of the osseous focus. Typical resection should be avoided if possible. Surgeons limit the operative procedure more and more to the removal of diseased tissue, in place of typical resection.

Amputation.—A mutilating operation is often the only choice in the treatment of diffuse tubercular osteomyelitis, as it offers the only chance for complete eradication of the disease and protection of the patient against general infection. It is contraindicated in the other forms of osteotuberculosis, unless complicated by tuberculosis of an adjacent joint, and even in such instances it should be limited to cases that have passed beyond the reach of a typical or an atypical resection.

ORTHOPÆDIC SURGERY.

BY V. P. GIBNEY.

GENERAL CONSIDERATIONS.

ORTHOPÆDIC SURGERY is that branch of general surgery which has to do with the prevention and correction of deformity. Its intimate association with mechanical appliances has rather limited its scope to the correction of deformity by such appliances, but the orthopædic surgeons of the present day have taken a more liberal view of the subject, and have felt it incumbent upon themselves not only to correct, but to prevent, deformity as well. The mode of correcting has been left largely to the individual surgeon, and for this reason operative as well as mechanical surgery has become a prominent feature. The practice of any branch of medicine or surgery presupposes a more or less intimate knowledge of diseases and their various manifestations; hence it is idle to talk of any one method of correcting to the exclusion of others.

When one considers the nature of deformity in general, and the mode of production, it is difficult to come to any other conclusion than this: that the orthopædic surgeon of to-day must be conversant with the nature of diseases which produce deformity, of the conditions which predispose to deformity, must himself be a good diagnostician, must have familiarized himself with the clinical history of disease, and must know what those conditions are which predispose to or lead to deformity. For example: the various diseases in and about a joint, whether involving the bone or the soft parts, must be carefully considered and be duly recognized.

The term *orthopædic* itself is well known to mean "to teach or educate straight." It is poor surgery to wait until distortions ensue before any effort is made in the direction of prevention.

Again, the deformities that result from various changes in utero, from accidents and injuries of various kinds, naturally come within the scope of this specialty. It is true that many deformities are not included within the scope of orthopædic surgery, such as hare-lip, cleft palate, strabismus, flexions of the uterus, etc., for the reason that such deformities, as a rule, have always been managed successfully by the general surgeon, the oculist, or the gynæcologist, and require no specially devised mechanical appliances to complete the cure. The day is passed when this specialty must rely on surgery for material assistance.

It is proposed in this article to consider the deformities of the head and neck, of the spinal column, of the upper extremities, and of the lower extremities, irrespective of the causes producing the same. To be a little more explicit: Torticollis; ostitis of the vertebræ, of the shoulder, the elbow, the wrist, the hip, the knee, and the ankle; periarticular

lesions of these joints; rotary lateral curvature; the deformities which result from paralysis and from rickets; and club-foot in all its forms,—will be considered.

Nomenclature, Etiology, and Pathology.—The deformities may be divided into congenital and acquired.

The congenital deformities include the larger proportion of club-foot, a smaller proportion of wry-neck, many deformities of the hands, arrest of development of the glenoid cavity and the acetabulum, arrest of development of the limb, and constriction of the limb, producing distortions.

The acquired deformities include such as depend upon bone or joint disease, periarticular diseases, traumatism, the various muscular asymmetries depending upon paralysis, whether cerebral, spinal, or peripheral, and many of the lesions of the nervous system and the distortions of rickets.

In the list of congenital deformities we have club-foot, divided into the following: talipes equinus, equino-varus, calcaneus, valgus and cavus, congenital dislocations of the shoulder and hip, and many cases of infantile spastic paralysis.

It is among the list of acquired deformities that the nomenclature has been so confusing. With the knowledge now possessed of the pathology of the larger number of bone and joint diseases, we are enabled to discard many of the older names with which we have become familiar, and apply terms more in keeping with the true nature of the lesion. For instance: we speak now quite freely of tubercular ostitis, of tubercular arthritis, of traumatic arthritis. We have learned that tubercular lesions are found in the epiphyses of the long bones, and that the deformities which ensue are exceedingly difficult to manage and are often incurable. If we know, therefore, that what formerly was an obscure affection about the hip or knee is really a tubercular lesion of the epiphysis or the bones entering into these joints, and apply terms which will at once indicate the nature of the disease, we naturally feel that a nomenclature on such a basis is far preferable.

Take the spinal column, for example. In place of the term "Pott's disease," or angular curvature, the term tubercular ostitis of the spine is of much more value, in that it enables us at once to forestall any deformity, provided we are sufficiently conversant with the nature of the disease. The same is true of the hip, and the knee, and the ankle. The term "hip disease" itself is sufficiently distinctive to one who has made himself familiar with all the diseases about the hip, but the term "tubercular ostitis of the hip," or simply "ostitis of the hip," is at once recognized as being the best term we can apply. Take the knee also: "white swelling" and "chronic synovitis" are not so significant as the term "tubercular ostitis of the knee."

While it is true that a certain number of excellent practitioners have as yet failed to accept the teachings of Koch, yet the great majority of surgeons, the world over, have long since adopted the earlier teachings of this great human benefactor. Synonyms will be given when the deformities of individual joints are considered.

The pathology which concerns this article is simple enough, and may be easily disposed of.

In the congenital deformities we know really very little of the pathology. The whole range of heredity is still under discussion. Able minds are as yet undetermined as to what part really heredity does play. Maternal impressions are really so intangible that we must dismiss them in considering any scientific subject. Mechanical obstructions are brought about in utero in various ways and at various stages of fœtal development. The study of embryology has thus enabled us to determine in a theoretical way the pathogeny of club-foot.

Without committing myself to any special theory, I may state that the theory which seems the most plausible is that of retarded rotation, propounded first by Essericht, and more fully developed by Berg of New York. It is assumed that the feet in early utero-gestation are in the position of equino-varus. It is further assumed that in the process of normal rotation mechanical obstruction is offered. This obstruction may depend upon the mother or the child, upon the nervous system or the circulatory system. The obstruction may be in the shape of muscular spasm at a time when a certain stage of rotation is present, or it may be in the shape of bands or certain dispositions of amniotic fluid within the uterus. If the obstruction persists long enough, the development of the fœtus will proceed without corresponding progress in rotation. An impediment thus having been established, the feet fail to unfold, and at birth we have the characteristic distortion, the degree depending upon the amount of obstruction and the period of fœtal life when such obstruction occurred.

Why an arrest of development of the acetabulum should take place we are unable to understand. The causes underlying this deformity are the same apparently as those which underlie cleft palate, hare-lip, and other similar deformities.

In discussing the pathology of acquired deformities the bacillus of tuberculosis is the all-important factor to be considered. If a simple cellulitis about a joint occurs, the deformity is, as a rule, evanescent. On the subsidence of this cellulitis the distortion disappears. Deformities which follow an irritable spine or certain neuroses in connection with the spine are much more persistent, yet clearly depend upon muscular spasm induced by such neurosis, and a diagnosis by exclusion usually suffices to make clear the pathology of such a distortion.

The presence of pus within the sheath of muscles, pus which comes from foci remote from the deformity in question, explains readily the condition which presents.

Fractures of bones in the neighborhood of joints, separation of epiphyses, and severe contusions in general produce a kind of deformity which is understood when the diagnosis is fully established.

While it is not always clear how the bacillus enters the system in an individual case, it is readily understood in this stage of medical science how the bacillus behaves in an epiphysis. Without any argument, therefore, we may assume that the bacillus has lodged in one or more centres of development on one or the other side of the epiphyseal line. We know the cancellous structure of the bone in this locality; its close resemblance to lung-tissue has often been suggested. An inflammatory focus is thus established, which focus increases in area, involving first a practically harmless area in the neighborhood of the joint, but as it

increases, frequently under the influence of trauma, we find involvement of contiguous tissues, such as the articular cartilage, the periosteum, the synovial membrane, the cellular tissue about the joint, and ultimately the muscular and cutaneous structures.

Let us take for example a case of ostitis of the hip and follow it through its different stages. We shall find symptoms corresponding very closely with the progress of the bone-lesion itself. The small focus or small foci, no larger than the head of a pin, give rise to obscure pains, to disability, and certain reflex muscular spasms. These make the little patient's gait unsteady, and, as a result, falls and injuries occur which would otherwise be avoided. The above signs may have been so obscure as to have escaped the attention of the parent, and have not come conspicuously into prominence until after one or two falls. In this way the fall is regarded as a cause of the disease, and the statement of the parent is regarded as evidence conclusive that the fall is the cause. This valuable point in the etiology has been so often elicited that I deem it unnecessary to dwell longer upon the subject. As this focus of disease increases, often under the influence of the trauma above mentioned, a larger area is produced, which involves a loss of structure and serves also as a receptacle for the inflammatory products. In other words, a small abscess is formed under the influence of still further trauma, to which is added the trauma of walking and the trauma of muscular spasm. It is possible for the disease to advance thus far without appreciable deformity, but the rule is flexion of the hip and *ab*- or *ad*duction, dependent not only on muscular action, but on an inflammation of the ligamentous structures immediately surrounding the hip, such inflammation producing contracture. It is easy for one to appreciate how walking on a diseased femoral neck will produce bending of this neck, thus altering its relationship with the shaft. The undue prominence of the trochanter major is thus explained. With the occurrence of exacerbations we have enlarged inflammatory areas, encroaching upon the joint proper and producing in the joint an increased amount of synovial fluid. This increase of fluid must find room, and flexion of the joint must occur. On the subsidence of the inflammation—or on its recession, probably better expressed—we have subsidence of symptoms and diminution of deformity. Finally, this small collection of pus must find its way into the joint more frequently, less frequently into the surrounding structures, and we have abscess. We have, then, the symptoms and signs of disease in the third stage.

The same processes which have been outlined are found in the spinal column, in the knee, the ankle, and bones involving other joints. The old theory, then, of trauma as the cause of bone and joint disease, in children at least, ought to be abandoned. While one by diligent search may find individual cases which would seem to depend upon trauma, the rule is just the reverse. It cannot be too strongly impressed, both upon the surgeon and upon the layman, that there is great danger to a joint consequent upon falls and injuries of various kinds *after the disease has appeared.* With a knowledge of the pathology of the present day there is no occasion for the hideous deformities resulting from the trauma of accident, the trauma of muscular spasm, and the trauma of locomotion.

Tubercular Ostitis of the Spine (Pott's Disease).

It is difficult for one who has been spared this affliction to properly appreciate the ravages and the distortions which tubercular disease of the vertebræ produces. The synonyms are: Pott's disease of the spine; Caries of the spine; Angular curvature of the spine; Spondylitis; Spondylarthrocace; Tuberculosis of the spine; Vertebral ostitis; and Tubercular ostitis of the spine.

The disease itself is characterized by fixation of that part of the column where the lesion is most active, an angular projection of the spinous processes in this neighborhood, a stooping posture, an interference with respiration, and an arrest of growth. These, in brief, may be regarded as the significant features of a case.

Etiology.—The predisposing causes of tubercular disease of the vertebræ are heredity, cachexia, and age. By cachexia is understood a condition formerly known as the strumous habit, now recognized as a mild grade of infection, dependent upon the presence of the tubercle bacillus or the elements of this bacillus. This cachexia may depend remotely upon hereditary influences, but more particularly is induced by impaired nutrition occurring in the wake of some one of the exanthemata. The exanthemata here include whooping cough, measles, scarlet fever, cholera infantum, and the developmental diseases generally. Nutrition is impaired in this way, especially if there be a long, tardy convalescence from any of these diseases. By age is meant the period between the second year of life and the tenth. The disease rarely, if ever, develops prior to the second year of life, and seldom develops after the tenth year. In adult life it is usually traced to trauma of some kind.

Clinical History.—In presenting the salient points in connection with the development of this disease it is well to bear in mind the anatomy of the column and its relations with the different portions of the trunk. The column itself is composed, as is well known, of twelve vertebræ, a vertebra consisting of a body, transverse processes, articular facets, spinous processes, a central canal, and grooves through which the nerves emerge from the spinal cord. The vertebræ themselves are held together by strong fibrous structures. These structures are reinforced by the articulation of the ribs throughout the cervical and dorsal region and the pelvic bones in the sacral. The furrows or grooves above mentioned form foramina of exit for the nerves. Again, certain muscles are attached to the periosteum in certain localities, and spasm of these muscles produces distortion of the column or distortion of the lower limbs under the influence of disease.

The Cervical Region.—In the cervical region we have a deformity of the head and neck which is in the nature of opisthotonos, not to the degree of the opisthotonos which accompanies cerebro-spinal meningitis, but in reality very much like this deformity. Another deformity depending upon disease in this locality is flexion of the head forward, with a disposition to rest the chin on the sternum. There is seldom that rotation of the head which is so characteristic of the ordinary torticollis with which all are familiar. The head is held backward and to the side a little—is carried carefully as the patient walks. The hand is frequently placed under the chin for support, occasionally against the occi-

put or the mastoid processes. In the face there is an expression of care and anxiety, which becomes a distinguishing feature in the early stage of cervical ostitis. The shoulders are held carefully, and the body itself is regarded with varying degrees of care, the degree depending upon the special vertebræ involved. There is usually a good deal of pain in the course of the occipital nerves, in the upper thoracic nerves, and occasionally in branches of the brachial plexus. There is a short respiration, an

FIG. 284.

Exaggerated deformity in cervical Pott's.

increase of pain whenever concussion or jar occurs—a disposition on the part of the little sufferer to avoid any such accidents. Traction on the head, carefully made, frequently gives relief, and in making an examination this test becomes important in diagnosis.

It is seldom one finds much deformity in the shape of a bosse where the cervical region is alone involved, but Fig. 284 represents an enormous deformity, which is very rare, and is presented in order to accentuate the changes which do take place in this region.

THE DORSAL REGION.—If the disease involves vertebræ below the first or second dorsal, there are very few head-symptoms. The patient presents the same degree of care in walking, holds the column rigidly erect, takes short steps, grunts a good deal, has pain in the region of the stomach, known as gastralgia ; resists any movements to bend the column. For instance : if he desires to pick up anything from the floor, he stoops with the hips and not with the back. In recovering himself from this stooping posture the hands are often placed upon the thighs, and he climbs up, so to speak, on his thighs. At night the sleep is disturbed by moans and

sharp cries occasionally, but the sharp cries must not be confounded with the shrieks of disease when it involves the hip-joint. Another symptom which is quite prominent is a disposition of the child to lie on its face or stomach across one's lap, and to avoid any play or romping which produces concussion. Where the disease is confined to the upper dorsal, and involves likewise the lower cervical, we have a deformity

FIG. 285.

Extreme lordosis with ribs overlapping.

known as pigeon-breast. There appears in time a deformity of the spinous processes known as angular curvature or kyphosis. This deformity in the upper dorsal, and mid-dorsal even, is much more conspicuous than the deformity in the cervical region. With the occurrence of the spinal deformity this thoracic deformity becomes more pronounced. As the kyphosis increases the ribs themselves participate in the distortion and approach by degrees the pelvis, so that in the advanced stages it is not uncommon that the free ribs overlap the iliac crests. An excellent illustration of the overlapping of the iliac crests by the free ribs is shown in Fig. 285. One can note also the lordosis in this advanced case.

When one considers the immense amount of cicatrization which must ensue upon tubercular inflammation of several bodies of the vertebræ, it is easy to understand how dwarfed a person may become, how restricted the thoracic cavity, how distorted the various organs in this cavity as well as the abdominal cavity, and how hopeless any brilliant relief to such a distortion. The shoulders naturally are raised, the head depressed between the shoulders, and the general contour of the whole trunk and head is one that cannot be mistaken. It is well to bear in mind that a certain

amount of lateral curvature accompanies the progress of Pott's disease in this region, as well as in the cervical and lumbar regions. Some writers make a good deal of the lateral deviation in the early stages, and seem to think that this is an important sign. While I have myself noted occasional cases of this kind for the past twenty-four years, I do not attach to it that importance which these gentlemen think it deserves.

FIG. 286.

Lateral curvature in lumbar Pott's.

This lateral deviation is well shown in Fig. 286, which was under the writer's care for two or three years. Curiously enough, a sister of this boy had a similar deformity from Pott's disease.

It must not be forgotten that the disease as it appears in any one of the regions under consideration follows the usual course of bone disease in general—namely, exacerbations followed by long remissions, the exacerbations themselves induced generally by trauma.

THE LUMBAR REGION.—It is difficult to dissociate disease in the dorsal from disease in the lumbar region, especially where the foci may involve both regions. Indeed, the foci may be confined altogether to the dorsal, and yet the compensating deformity may include the lumbar, and *vice versâ*. The general signs in the lumbar region are about the same as those in the dorsal and the cervical—namely, stiffness, pain, the avoidance of concussion, etc. etc. The gait, however, is peculiar, and is suggestive often of disease in the neighborhood of the hip-joint. The patient favors one limb, and even before any abscess appears there may be contraction of the psoas and iliacus groups of muscles on one or the other side, and we have flexion of the thigh with inability to completely extend. The signs are usually obscure; that is, we find much disability, much impairment of motion, sometimes long before any kyphosis appears. The vertebræ are bound so intimately with the pelvis that it is unusual to get a high degree of deformity in the lumbar region. The pains are referred to the sacral plexus of nerves and are usually symmetrical.

Variations and Complications.—The symptoms above outlined belong to the classical cases. Any symptomatology would be incomplete without a reference to the odd cases and to the complications which so frequently arise.

The variations in the clinical features of Pott's disease are found in the different regions pretty uniformly, and depend largely upon the mildness or severity of the initial lesion. There may, for instance, be groups of symptoms that are so slight and of such brief duration that

one is thrown off his guard in recognizing the malady. These slighter symptoms are followed by a long period of quiescence in which the patient does not complain of anything. If one suspects the existence of disease, a personal inspection will often reveal a little irregularity of the spinous processes, with impairment of function of this portion of the column. This quiescent period may vary, therefore, from a few weeks to a year. In the cervical region a peculiar attitude of the head, with some enlargement of the cervical glands, may be all that can be recognized. In the dorsal region there may be a slight antero-posterior curvature of the spine, resembling very much the deformity of rickets. There may be a persistent lateral curvature, and the importance of this sign will depend much upon the age of the patient.

The symptoms above recorded refer more especially to the disease as it occurs in children and young people. In adults we have spinal tenderness the rule, while in children it is the exception. There are exceptional cases where the progress is very rapid and where the symptoms are very acute. This branch of the subject will be dealt with more fully in discussing the diagnosis. Even in children there may be almost an entire absence of pain throughout the course of the disease.

The complications are muscular deformities, impairment of the respiratory and cardiac functions, abscess, paralysis, tubercular meningitis, and amyloid degeneration.

The muscular deformities may exist in the neck, in the ilio-costal spaces, and in the lower limbs. The head, from lack of support, may become distorted, and the position, long maintained, induces muscular shortening, so that occasionally one finds a wry-neck which is clearly a complication of the cervico-dorsal Pott's. The muscles attached to the upper part of the shoulder may become shortened in the same way, and a peculiar shrugging of the shoulders may persist indefinitely and resist all kinds of treatment. Illustrations are given of these deformities in Figs. 284 and 286.

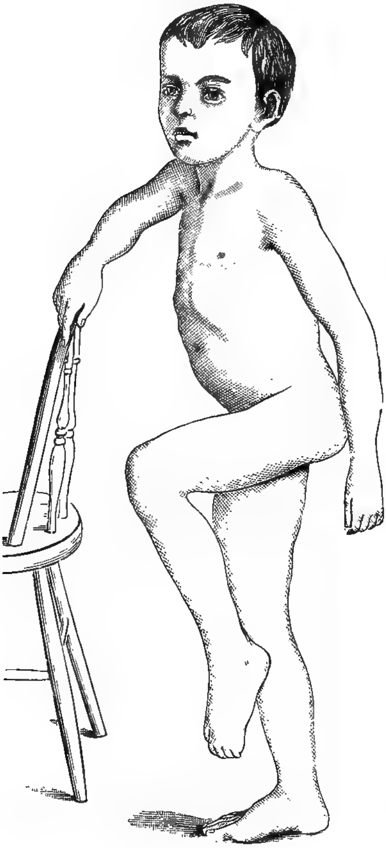
The ilio-costal space usually escapes any muscular deformity, but in rare instances we have shortening of the muscles on one or the other side, and a peculiar deformity results. This is shown in Fig. 285.

A very common deformity about the hip is due to shortening or spasm of the psoas and iliacus muscles, whether abscess is present or not. It must be remembered that these muscles take their origin indirectly from the bodies of the last dorsal and first lumbar vertebræ, and that spasm is easily induced when disease involves these vertebræ or even vertebræ contiguous thereto. The gait thus produced is similar to that in what is known as hip disease, and may range from a very slight defect to a hideous deformity. Deformity of this kind is shown in Fig. 287. Depending upon muscular deformities in the psoas and iliacus are deformities of the hamstring muscles, and it is not inappropriate to speak of these as complications of Pott's disease.

The respiratory and cardiac disturbances not infrequently arise from involvement of the nerves as they emerge from the cervical and dorsal vertebræ, also from the bone-deformity. The alterations in the chest-walls induced by the dorsal disease necessarily interfere with the action of the lungs, and we have short breathing, difficult breathing, and other symptoms of like nature.

The disturbances that result from the presence of abscess are legion, and it is difficult to enumerate all the complications that may depend upon the abscess complication alone. In the cervical region we have the abscess presenting on one or the other side of the neck, usually involving the glands and often re-

Fig. 287.



Psoas contracture.

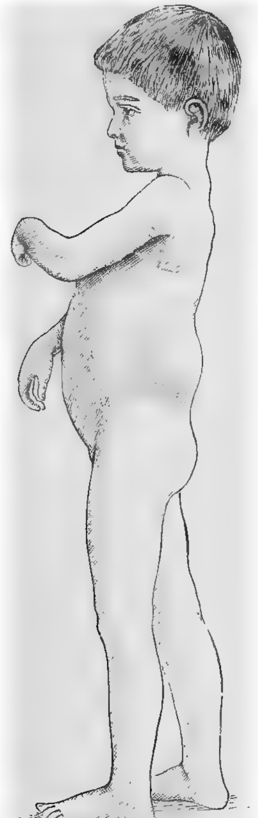
Fig. 288.

Cervical abscess.

garded as glandular enlargement (Fig. 288). When pus escapes from the cervical vertebræ or the last cervical and first dorsal, its usual site is in the cervical triangle. When it fails to find this mode of exit, it is imprisoned back of the pharyngeal wall, and we have post-pharyngeal abscess, which presents at times most distressing symptoms. In the dorsal region abscess may be imprisoned in the cavity of the bosse and press upon the pleura and lung, or it may burrow along the anterior surfaces of the ribs, and press in this way upon lung-tissue. Physical diagnosticians not infrequently have found evidences of pulmonary consolidation on one or the other side of the column. A careful diagnostician, however, is able to recognize the distinction between compression of the lung and inflammatory consolidation. The abscess coming from dorsal vertebræ does not always behave in this way. It finds its exit between the ribs and presents as a tumor on the chest-walls posteriorly, or it may extend down the anterior surface of the column and present in

the lumbar region (Fig. 289). It rarely presents in the anterior portion of the thorax, and, while such cases have been mentioned, I fail to recall a single instance where a spinal abscess has appeared in this locality. It may be seen in almost any portion of the posterior walls of the thorax

Fig. 289.



Lumbar abscess.

Fig. 290.

Psoas abscess.

from the neck to the lumbar region. Abscess coming from lumbar or sacral vertebræ appears in the sheath of the psoas muscle, in the groin, in the sacral region, in the ischio-rectal region, and in Scarpa's space (Fig. 290). It occasionally is seen in the post-femoral region, and may appear as far down as the popliteal space.

The pain and distressing symptoms which are usually regarded as symptomatic of abscess exist in the early stage; that is, when the pus is seeking an exit from the caseous mass in immediate contact with the vertebræ. After the escape of the pus these acute symptoms are no longer present, and it is well to remember that the tumor itself is not accompanied by pain or anything more than mechanical annoyance. The laity have an impression that all abscesses are painful and accom-

panied by most distressing symptoms, while the surgeon has learned to distinguish between hot and cold abscess. If the contents of the sac become in any way infected, then the skin and tissues covering the sac become red, indurated, and exceedingly painful to the touch. With these symptoms we have marked constitutional disturbance, such as restlessness, loss of appetite, marked febrile reaction.

Complications which are the direct result of the abscess are ulcers and sinuses. These the more frequently follow spontaneous opening of an abscess, although they may, and often do, follow the most careful attempts at aseptic surgical procedures. The sinus itself may persist for a few weeks or many years. It is difficult to lay down any rule for the duration of a sinus. After it has existed for two or three years it becomes a safety-valve, and its temporary closure is followed by signs of sepsis which make the patient very uncomfortable. Relief follows as soon as the drainage is re-established. Abscess may open into the pharynx, into the pleura, into the lung, into the abdominal cavity, into the intestine, into the vagina, into the rectum, and into the bladder.

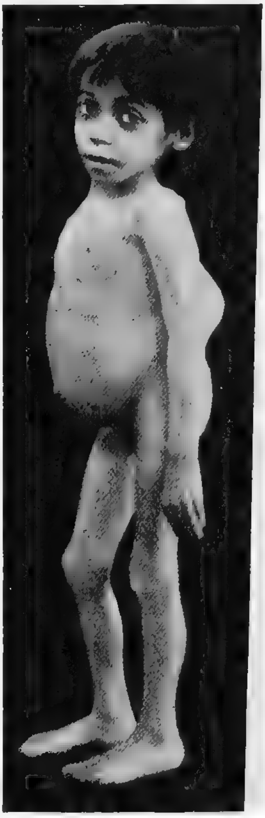
A not unusual complication is paralysis from compression-myelitis. The percentage is about fifteen. It occurs more frequently—indeed, almost exclusively—in those cases where the cervical and cervico-dorsal regions are involved. Pathologically, it is a pachymeningitis externa developed from a caseous ostitis of the bodies of the vertebræ. With this pachymeningitis we have sometimes an interstitial myelitis. The deformity is not necessary to the production of a compression-myelitis. The symptoms are a feeling of fatigue in the limbs, a dragging of the feet, stumbling, and a certain degree of spasm. The spasm is a later symptom, and when fully developed we have a very marked exaltation of the reflexes. There is seldom any impairment of sensation, although delicate tests serve to bring out more frequent impairment of sensations than is generally supposed. The bladder is more frequently affected than the rectum. In advanced cases cystitis may result. The duration of the attack may be a few weeks or it may extend over many years. The average duration is about eight months. This complication is generally self-limited, though treatment has a great deal to do with hastening the recovery. Death, when it does occur, is from progressive myelitis.

The treatment should be directed to the spinal column, and *adequate protection* should be given throughout the entire course of the complication. Counter-irritation is useful, but not by any means a specific. The writer believes that large doses of potassium iodide will cure the greater number of cases. The mode of administration is to begin with small doses in mineral water of some kind, and increase rather rapidly up to from fifty to a hundred grains three times a day. The potash is well borne in such cases, and certainly yields admirable results.

Tubercular meningitis is a complication of all tuberculous bone lesions, and does not occur any more frequently in the course of Pott's disease than it does in disease involving the larger joints. Meningitis may appear at any stage of the disease, and is not more common in one than in the other. My own experience leads me to state that about 8 or 10 per cent. of all tuberculous lesions of the bones develop, sooner or later, tubercular meningitis.

Amyloid degeneration, while not, strictly speaking, a complication of Pott's disease, is more particularly dependent upon prolonged suppuration, which is itself a complication of the vertebral disease. The course of amyloid disease is as follows: First, the cachexia of prolonged suppuration, pain and distress varying in degrees of intensity in the hepatic region, a low specific gravity of urine, enlargement of the liver, albumin and hyaline casts in the urine, œdema of the face and extremities; finally, general anarsarca. Fig. 291 well represents the gross appearances of a patient before the advanced stages of amyloid degeneration.

Fig. 291.



Amyloid degeneration.

Diagnosis.—It is impossible to over-estimate the importance of diagnosis, not only in tuberculosis of the spine itself, but in all of the so-called joint diseases of childhood. The nature of the disease is so well known, and the means of relief so satisfactory in competent hands, that an early diagnosis may be regarded as the most important step in the management of the disease. Fortunately, we are enabled to recognize tuberculous foci in bones long before any deformity appears. It is nevertheless true that a large number of cases come to treatment after the appearance of the deformity. This is due not so much to the ignorance of the surgeon or the physician under whose observation the patient first comes, as it is to lack of careful examination. to a slovenly mode of examining patients, and to the utter neglect of any routine method of examining. The best routine method to adopt is the examination of the patient in a state of nudity, an inspection of the column itself, and a test of the functions of the column. This, of course, presupposes a knowledge of the normal functions of the column and a patient inquiry into the symptoms.

The history naturally comes first in the course of the examination. One can readily learn the behavior of the patient at home, whether the disposition has been to protect the spine against trauma; the locality of the pains; the presence or absence of pains in the course of certain nerves; the reference of such pains to individual nerves; the interpretation of such pains; the character of the sleep, whether it is disturbed or not by groans or cries; the attitude the patient assumes during the day—for instance, whether he prefers to lie prone on the floor or on a table or across the mother's lap for relief of certain slight paroxysms; whether he cries when lifted by the arms or by the body; whether he walks cautiously and steps cautiously. When the evidence is all in, a careful summing up of the salient features, a grouping of symptoms and signs, will enable one to make a diagnosis and locate the lesion beyond any reasonable doubt.

One must remember that the disease itself is chronic in nature—that there is no sudden invasion, no chill or very acute symptom, but that there is a gradation of symptoms from insignificant ones to those of greater magnitude.

In the different regions we have—

1. *Cervical.*—The position of the head; the reflex spasm of the neck-muscles; the pains in the course of the occipital nerves; an elevation of the shoulders; an unnatural rigidity of the column itself, with often lateral deviation in the dorsal or dorso-lumbar; pain on concussion; occasionally a uniform enlargement in the post-pharyngeal wall, which can be made out by the use of the finger, and occasionally tenderness in this locality. The signs gained by the finger in the pharynx, however, are not of much value unless associated with those above named.

2. *Dorsal.*—Gastralgia, pain on concussion, a moderate rigidity of the column, a grunting respiration, and a disinclination to bend forward. For instance, when one requires a patient to pick an object from the floor, in place of bending forward naturally to pick up the object, he assumes slowly a squatting attitude, puts the hand out to the side, and completes the act, making a peculiar grimace of the face at the same time.

3. *Lumbar.*—An unusually erect attitude, associated with a certain degree of lordosis; an inequality of step, dependent upon a little deformity of one or the other hip; slight pain on concussion; pains in the course of the sciatic or anterior crural nerves; and, on closer inspection, a real lordosis. This latter sign has long been regarded as due to an increase in the thickness of the vertebræ depending upon hyperæmia, and a swelling (?) of the intervertebral disks.

The mode of testing the functions of the column, whether the disease is suspected in the dorsal or the lumbar, or both, is to place the patient prone on a table, and, with one hand resting across the back, move the hips and thighs with the other hand. All the functions of the column can be tested in this way, and the presence or absence of reflex spasm can be noted. In the lumbar region especially it is important to test the functions of the hips, using hyper-extension. Reflex spasm can be recognized very early in the course of the disease, and is fortunately confined to one or the other side, not existing in both at the same time.

It will be noted that nothing has been said about pressure along the spinous processes as a means of diagnosis. I have purposely avoided this, because so many surgeons rely upon this as an important means of recognizing disease in the bodies of the vertebræ. It should be borne in mind that the disease is not in the spinous processes—is not, except in rare instances, in the lateral masses—but is always in the bodies of the vertebræ, and that pressure upon the spinous processes so remote from the site of disease will not cause pain. An exception may be made in the case of adults. There is tenderness on pressure over the lateral masses and spinous processes in vertebral disease as it affects the adult. It is not easy to explain this difference, yet the fact is as stated.

Diagnosis becomes comparatively easy in the stage of deformity, yet it is necessary to distinguish between the deformity of rickets and that of bone disease. The kyphosis of rickets is a uniform posterior curvature involving an entire region, usually the dorsal, frequently the dorsal

and lumbar combined. There is no sharp angular projection in the rachitic kyphosis. In the kyphosis of Pott's disease one spinous process usually stands out prominently, and the neighboring ones project to a smaller degree, so that we have an angular deformity rather than a curve. In the rachitic kyphosis hyper-extension of the column either causes complete recession of the deformity or a marked diminution of the same. In the kyphosis of Pott's disease there is no recession of the bosse, but the compensating curves above and below may be overcome. In the kyphosis of rickets there is a certain degree of flexibility always present. In that of Pott's disease there is no flexibility of the column in the region involved.

Among the diseases from which to distinguish are rachitic kyphosis, already mentioned, malignant disease of the vertebræ, perinephritis, disease in and about the hip, lumbago, the various spinal neuroses, cervical pachymeningitis, and spondylitis, whether rheumatic or traumatic.

Malignant disease of the vertebræ is usually not marked by any deformity, or, at least, the angular deformity of Pott's. There is decided tenderness, excruciating pain in the course of nerves, extreme tenderness on handling or moving the patient about, and a history usually of malignant disease in other parts of the body. Naturally, the female sex presents the larger number of cases of malignant disease of the vertebræ, and it is easy usually to find the history of a breast-tumor. In Pott's disease there is not that prolonged suffering without remissions which is so common to malignant disease of the vertebræ. The usual course of exacerbations and remissions is an important element in differential diagnosis. In malignant disease the severity of the pain seems inconsistent with the amount of disease in the back. There are various disturbances of the genitals, various neuroses of the lower limbs; the skin is hyperæsthetic, and, while there may be remissions, they are not complete, and exacerbations recur on slight provocation. Where any reasonable doubt exists efficient treatment for Pott's disease may be employed, and failure to give relief makes the case still more suspicious and enables one soon to arrive at a diagnosis. Again, the cancerous cachexia may be present. This is so often absent in aggravated cases that it is not very reliable as a diagnostic feature, because in aggravated cases of Pott's disease there is also a cachexia which it is difficult to distinguish from the cachexia of malignant disease.

A number of years ago I had quite a run of cases of perinephritis in hospital practice, but of recent years they have not been so common; yet occasionally one finds a perinephritis presenting unusual fulness of the dorso-lumbar spine, with the lateral deviation which is regarded as important as a means of diagnosis, and it is difficult then to distinguish this acute inflammatory lesion of the soft parts around the kidney from Pott's disease. The points in differential diagnosis are the following: Acuteness of invasion; persistence of febrile disturbance; early deformity of the hip or back, say within two or three weeks from the first symptom; the resistance to extension of the hip; the presence of a tumor, or at least marked dulness, in the ilio-costal space, encroaching at times on the column itself and producing a lateral deviation in the opposite direction. None of the above signs really belong to Pott's disease.

The diseases in and about the hip which present at times features in

common with those of Pott's disease are sacro-iliac disease, which is exceedingly rare, a periarthritis of the hip, ostitis of the hip, perityphlitis, in rare instances appendicitis. In sacro-iliac disease the spinal column moves quite easily under manipulation; there is no deformity of the vertebræ; the tenderness is in the neighborhood of the sacro-iliac junction; the gait is peculiar—that is, a kind of spraddling walk. In periarthritis there is absence really of spinal symptoms and presence of an infiltration around the hip, which is tender to pressure, which is of brief duration, and which is accompanied by more constitutional disturbance than one gets in Pott's disease. It is only necessary to mention the other lesions of the hip, as a careful examination will always enable one to make a differential diagnosis between ostitis of spine and ostitis of hip. In exceptional cases the abscess from the hip may have burrowed up into the gluteal region and have relieved the more acute symptoms, but the presence of the abscess itself prevents a careful comparative examination of the hip. It is more common to find men erring in diagnosis of hip disease where the abscess comes from the vertebræ and extends down the gluteal region or into Scarpa's space, thus interfering with the proper examination of the hip.

Lumbago affects adults as a rule, rarely affects children, comes on rather suddenly and after exposure to cold or a strain of some kind, is unattended with deformity and many of the symptoms and signs belonging to Pott's disease. A lumbago resulting from an old sprain is sometimes very difficult to differentiate from Pott's disease, and requires a very close examination with the employment of all the tests.

The neuroses of the spine may be summed up for practical purposes in one term—irritable spine or spinal irritation. We find this affection in women, and it is sufficiently marked by a variety of symptoms, such as tenderness over bony prominences, the sternum, the shoulders, several points along the spinal column; is rarely marked by tenderness on concussion; is usually without deformity; and occurs, as a rule, in neurotic subjects. In all cases, as a rule, the spinal column is normally flexible.

Pachymeningitis is exceedingly rare, occurs in the cervical region, produces many of the signs of Pott's disease, but its course differs materially in the involvement of the nerves of the upper extremities. Many years have elapsed now since I have encountered a typical case of pachymeningitis, yet there is an occasional report of one in literature. The deformity of the head is that of flexion, rather than opisthotonos or variations of opisthotonos.

Spondylitis is a term employed by neurologists to represent a group of symptoms which really belong to irritable spine, but which seem to have some distinct cause, such as a periostitis of the transverse processes or spinous processes—a periostitis which interferes with the nerves at the foramina of exit, and which is either traumatic or rheumatic. Spondylitis is seen most frequently at the various baths in Europe, and has been written up long before the term was employed by American surgeons as a suitable one for Pott's disease.

Treatment.—The principles of treatment which have been recognized as paramount are—immobilization of the column, protection against trauma extending over a long period of time, good hygienic surroundings, and constitutional measures. In order to appreciate the force of

the principle of immobilization or fixation one must be able to make a diagnosis before the stage of deformity, and to look upon a case of Pott's disease as one of "broken back." To successfully treat a case one must be a good diagnostician, and one can be a good diagnostician if a routine method of making examinations is always observed. One must have a due appreciation of the clinical history, and then the term "broken back" is not so inappropriate after all. If one is called upon to treat a broken arm or a broken leg, he naturally resorts to the best means of fixing the broken limb in the best possible position, and of retaining this fixation until repair shall have taken place.. Now, in Pott's disease, instead of an immediate solution of continuity of the osseous structures, we have a gradual solution of continuity, dependent upon the progress of the tubercular process, and deformity must occur as a result of this solution of continuity. Fix the spine, then, before any such disastrous result, maintaining the fixation, under all circumstances, over a sufficiently long period of time for repair to take place. It must be remembered that destruction of the bone results from, first, the tubercular process; second, the pressure of contiguous healthy vertebræ falling one against the other and maintained in this abnormal position by muscular spasm, a shortening of fibrous structures, etc. etc.

In the cervical and cervico-dorsal regions the indications are to relieve the diseased vertebræ from the weight of the head. This can be done, not so much by traction in the upward direction, as by a combination of traction and tilting backward of the head, so that the weight will be transferred from the bodies to the transverse processes. Another indication is to overcome the muscular spasm of the anterior thoracic muscles, which act chiefly upon the shoulders. The authorities differ in their views as to the vertebra in the dorsal region above which the head support is necessary. Some believe that the head should be supported when the disease is as low as the eleventh or twelfth dorsal, while others again maintain that disease below the sixth or seventh does not require any such support. My own views coincide with those who hold the latter opinion.

The period of this fixation and protection must not be lost sight of. One should remember that the disease itself extends over a period of from three to five years, and that to ensure the best results treatment should be continued not only during this period, but a supplementary supporting treatment should continue in cases where the dorsal and dorso-lumbar regions are involved, in order to prevent what are known as compensating deformities. Ordinarily, from two to three years is long enough for continuous fixation of the column. By continuous fixation is not meant a support which cannot be removed, and is not removed, from time to time, for purposes of cleanliness, but removal of such apparatus must be made under certain precautions—precautions which ensure a maintenance of the good position.

By good hygiene is meant good living, regularity in diet, and all those conditions of climate which serve best to check the ravages of tuberculosis. If, for instance, a patient can afford changes of climate, then the mechanical treatment should be such as will enable him to get the benefit of such changes.

By constitutional treatment is understood nutrients, tonics when the

health is below par, and all other means for building up a system which must, of necessity, be impaired.

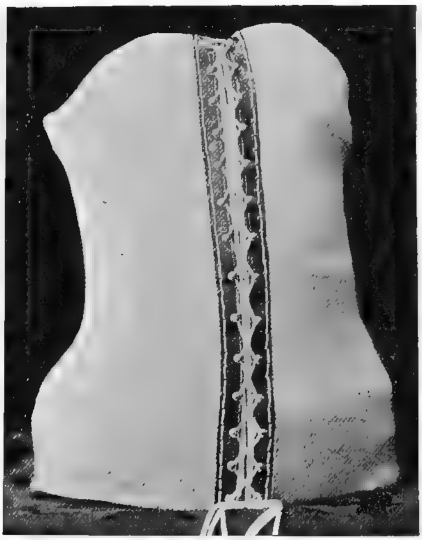
Unfortunately, all cases are not diagnosticated early, and treatment is not begun before deformity and complications appear. The principles of treatment, however are the same. The deformity itself calls for the same amount of protection against increase; complications demand often surgical interference, and at times it is best not to interfere surgically. The management of a case, therefore, demands mechanical, constitutional, and surgical measures of relief.

After a very close study of the different methods of treatment, I am convinced that plaster of Paris offers to the general practitioner the best agent with which to construct support for the spinal column. The numerous objections offered are really trifling when one considers the immense advantages. Good plaster of Paris can be obtained in any part of the country; the smooth or cross-barred crinoline is easily secured. I am willing to admit the necessary skill in applying plaster is not always at hand. Still, one can learn how to apply plaster if ordinary intelligence and application be employed. The process has become very simple. It is no longer necessary to completely suspend the patient. The dinner-pad is seldom employed. The details of a jacket or corset made of plaster are as follows: Secure the best dental plaster; rub this well into the meshes of strips of crinoline from two to four inches in width and six yards in length; get, if possible, crinoline that is sized with starch and that is free from glue: if doubt exists as to the sizing, wash the strips, and let them dry before incorporating the plaster within the meshes. When the bandage is rolled—and it must not be rolled tightly—wrap a bit of tissue-paper around it and place it in a tin box with a good cover. A bandage thus prepared and thus laid away will be good for use from one to two or three weeks later. It is better to use bandages made the same day. Still, this is of little consequence if the above precautions are taken.

The patient should be partially suspended or simply stretched, with a skin-fitting shirt over the body, and the salient points, such as the projecting spinous processes, the iliac crest, the posterior superior spinous processes, the free ribs, if they project, lightly padded with eider-down cloth or piano felting. The eider-down cloth answers very well. With one or two assistants to steady the patient and keep the shirt drawn taut over the body the plaster may be applied in the following way: Take from a pail of warm water, into which two or three bandages have been placed on end, one bandage. Begin at the pelvis and roll the wet bandage around the body, overlapping halfway at every turn. Weak points, as one goes up, naturally present, and these can be reinforced by reversing the bandage two or three times. Make it a point to rub every layer well with the hand before the next layer is applied. In the case of young girls or women mammary pads of cotton batting should be employed next the skin. These can be subsequently removed. All jackets should extend from the trochanters up to the axillæ, and should be made rather heavy at top and bottom. No plaster jacket need be more than one-eighth of an inch in thickness. At some points where special strain comes it may be three-sixteenths of an inch, but it is a good plan not to exceed one-eighth. No salt or alum should be put into the water

to assist the hardening process. An ordinary palm-leaf fan, when all the bandages have been rolled about the body, will aid one in securing the necessary hardening. Before the patient is removed from the swing the top and bottom of the jacket may be trimmed, and the whole process completed while the back is extended. Where a head-spring is necessary, the framework can be incorporated in the plaster. Where a corset is advisable the jacket can be cut down through the centre in front before it is thoroughly dry. The jacket and under-vest are removed together, the top and bottom trimmed out to correspond to the axillæ and the thighs, and the edges in front approximated, while a roller bandage serves to hold them in apposition. The baking process occupies about twenty-four hours. This is done over a kitchen range on the perforated sheet iron used for drying plates. Later still, the shirt can be turned up over the jacket, stitched at the top and at the edges in front. A binding of chamois, kid, or rubber plaster can be applied along the front edges before the leather strips are attached. These leather slips contain shoe-hooks, and ordinarily are secured by means of heavy thread (Fig. 292). Where the cervical region or cervico-dorsal as low as the seventh or eighth dorsal region is involved, a chin-rest of some kind, or a head-spring, commonly known as the jury-mast, is employed, and the framework for this is inserted between the layers of the bandage. In other words, the framework is fitted after a few turns have been made, and the remaining turns are carried over this, so that a good support is thus obtained. The completed jacket and head-spring is shown in Fig. 293.

FIG. 292.

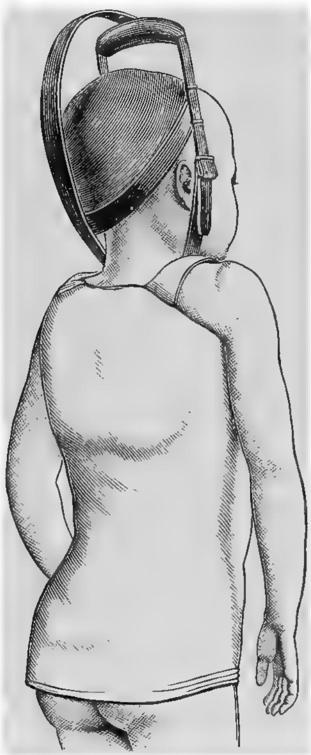


Plaster corset.

I have not included the directions for the manufacture of the wood corset, the woven wire, the raw hide, the leather, or the manila paper and glue. All corsets of this class can best be made by the instrument-maker over a cast which has been supplied by the physician or surgeon. All such supports may be classed with the steel spinal braces, because of the extra labor required in their construction. The steel brace which is the most generally employed in this country is the Taylor spinal assistant, an illustration of which is presented in Fig. 294. The Taylor brace has been modified a good deal, and it is really a very serviceable support, because modifications can be made. For instance: scapular pads may be attached, and in this way the scapulæ held in good position. As counter-pressure, however, for scapular pads the acromial cups are best employed, and Dr. Whitman has made a very useful com-

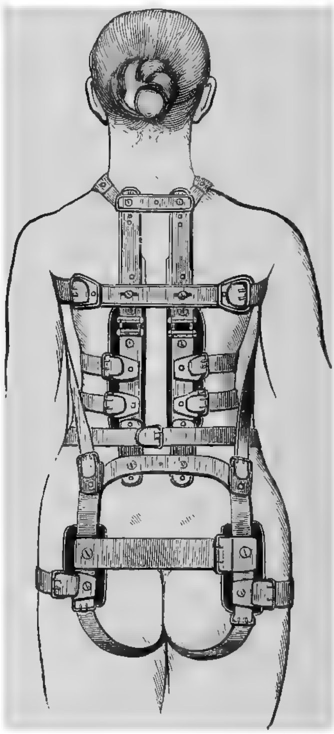
bination of these two attachments to this apparatus, as shown in Figs. 295 and 296. Curiously enough, these acromial cups were used by Banning many years ago, as shown in Fig. 297. While indulging in historical lore, an old brace was used in 1744, an illustration of which is furnished in Fig. 299. Nuck's spinal brace with head-spring, as shown in Fig. 298, is certainly an improvement, so far as appearances go, on the woven-wire spinal brace with jury-mast. Next, perhaps, in frequency, is the Knight spinal brace. The surgical instrument-makers furnish the directions for measurement, but with all the instructions

FIG. 293.



Plaster jacket with head-spring.

FIG. 294.



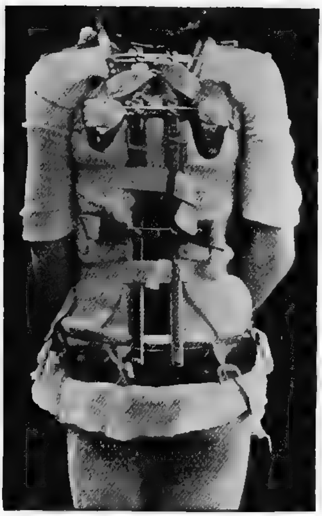
Taylor spinal assistant.

given it is exceedingly difficult, for one who is reasonably familiar with the apparatus, to get a satisfactory appliance for his patient. The steel bars and encircling bands should be fitted before any upholstering is done. The measurement should depend altogether upon the length of the bars the individual surgeon requires for his case. No hard-and-fast rules can be laid down for measurements for apparatus. If the surgeon has a clear idea of just what he wants to meet the indications, he can, with a tape-measure, measure for the uprights and the cross-pieces, can mark off just where he wants any padding, where rivets should come, where shoulder-straps, head-supports, etc. etc., and can make a rude

drawing indicating the points on the outlines where pads, cross-bars, straps, etc. should come.

The treatment of abscesses depends largely upon the efficiency of the protection given to the spine by apparatus. If the spine which I have chosen to call a broken back is well splinted, the abscess will either be insignificant or easily managed. In my own hands the aspirator has proved of greater value than incision. So long as the abscess itself is not in the way of the requisite support it may be left alone. Nearly all can be easily aspirated. My own plan is to get the skin overlying thoroughly aseptic, have my needles sterilized, crowd the parts closely down over the tumor, and thrust the needle into the sac; evacuate until the needle is filled with plugs of cellular tissue, remove the tubing, thrust a

FIG. 295.



Whitman scapular pads.

FIG. 296.

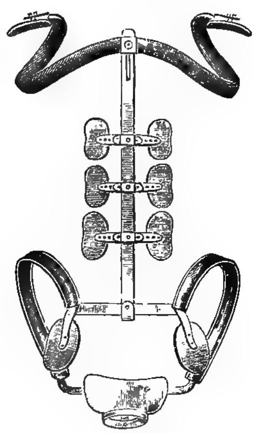
Whitman shoulder-cups.

blunt wire rod through the needle to remove the tissue, reapply the tubing to the proximal end of the needle, and withdraw more pus. After the sac has been pretty well emptied suddenly withdraw needle, paint the opening with collodion, strap the parts well over an area of two or three inches, and enjoin rest in bed for from six to twelve hours. In adult patients I employ an ice-bag over the part aspirated for several hours. My own experience in injecting agents of various kinds has led me to abandon such treatment and resort to aspiration alone. If refilling takes place rapidly, and if the abscess for any reason becomes "hot," then an incision is made. The length of the incision will depend somewhat upon the locality of the abscess. Wherever it is possible a long incision should be made, the sac-walls should be curetted and thoroughly flushed until the fluid is clear, and then the opening stitched

together with a small point for temporary drainage. Orthopædic surgeons who have become adepts in adjusting steel braces find very little occasion for interference with these pus-collections. A number disappear by resorption. A certain number open spontaneously, and either close within a short time or continue to discharge through a sinus. I must enter a protest against the free incision of an abscess in adult cases of Pott's disease. My own experience, supplemented by a pretty large observation, leads me to believe that it is next to impossible to avoid sepsis sooner or later, even by the most skilful operators.

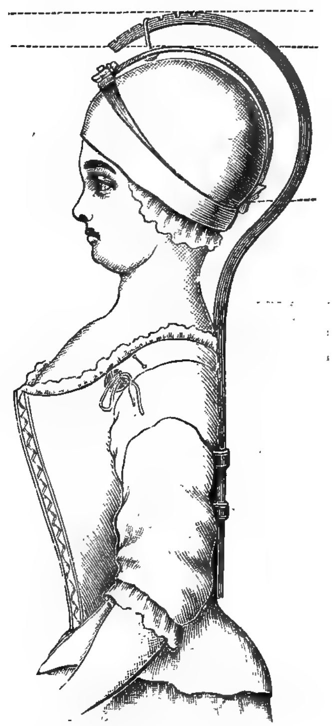
The deformities of the hip and thigh which result from muscular contraction or contracture usually right themselves after the case comes under good protective treatment. There are very few cases of psoas contraction that, in my judgment, require any special treatment, yet where these contractions persist and contracture has become fully established the deformity may be corrected either by traction with weight and pulley or by subcutaneous or open incision. A treatment that has attained an ephemeral degree of popularity is the direct incision upon the bone and removal of the tuberculous foci. While this may be a step in the right direction, the mortality which is already to the credit of this operation is rather against its continuance. At least, it is against my own suggestion in an article of this kind.

Fig. 297.



The Banning brace.

Fig. 298.



Nuck's spinal brace.

To recapitulate, then, the treatment should be—

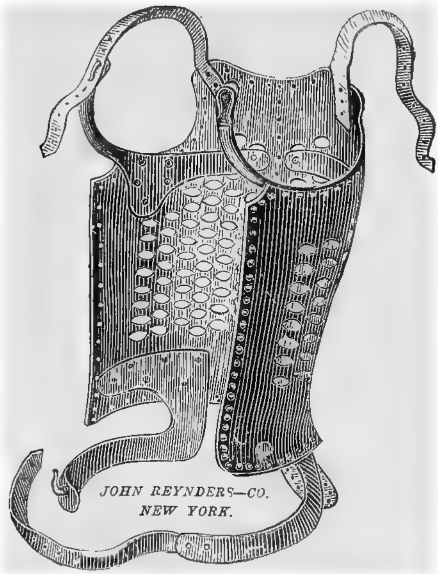
(1) Protective, the protection absolute and extending through a period of from twelve to eighteen months.

(2) At the expiration of the eighteen months, if no exacerbation has

occurred within the past six months, a corset-jacket may be substituted for the solid jacket, and the protection need not be so complete.

(3) After a period of two or three years' treatment certain precautions may be omitted, such as having the patient sleep in the support at

FIG. 299.



Old form of spinal brace.

night, or having him either suspended or lying prone when the apparatus is removed.

(4) The support to be used by the average practitioner, whether he be medical or surgical, is the plaster-of-Paris jacket or corset.

(5) The complications are to be treated expectantly, as a rule—the compression-myelitis by rest and by the avoidance of electricity of any kind. Internal medication may be employed, my own preference being potassium iodide in large doses. The Paquelin cautery is frequently useful, but simply as an adjunct.

(6) Abscesses should be let alone, unless they interfere with the application of apparatus or become painful or distressing, and interfere by their size with the function of important organs or other precautions.

(7) Aspiration is preferable to incision: incision should be employed when aspiration fails.

(8) Deformities resulting from muscular contractions require no special treatment unless they become fixed by contracture.

(9) Good hygienic surroundings, nutrients in abundance, good climatic influences whenever possible.

LATERAL CURVATURE OF THE SPINE.

The synonyms for lateral curvature of the spine are Rotary lateral curvature, Scoliosis, and Spinal curvature. It is not customary to intro-

duce Pott's disease and lateral curvature in such close connection, but one can give a better idea of the deformities that belong to these two orthopædic subjects by introducing them in this order.

Definition.—Lateral curvature of the spine is not a disease of the vertebræ, but is, more properly speaking, a lack of symmetry of the two sides of the body brought about by a rotation of the vertebræ on the vertical axis, this rotation of itself inducing a lateral deviation of the column. So that the term "lateral," as applied to the curvature, is a correct one, and is sufficiently significant to enable one to distinguish the curve from the angular deformity of Pott's disease; which deformity, when it rarely assumes the shape of a curve, is an antero-posterior curve.

Etiology.—There is really no deformity of the human body which presents more difficult problems etiologically than does scoliosis. The various theories may be enumerated in the following order: Congenital asymmetry of the articular facets of the lateral masses; rhachitic changes in these facets, inducing the asymmetry; faulty positions long maintained during the early period of life; muscular asymmetry dependent upon some obscure disturbances of the nerve-centres; faulty attitudes at school, either in standing or sitting. In tracing the causes in individual cases I have been impressed with the frequency with which lateral curvature

FIG. 300.

Lateral curvature from myositis ossificans.

develops in very early life, and it has occurred to me that the greater number might be traced to rhachitic changes, such changes brought about by carelessness in supporting the child while the bones were yet soft, and the failure on the part of the mother or nurse to maintain correct atti-

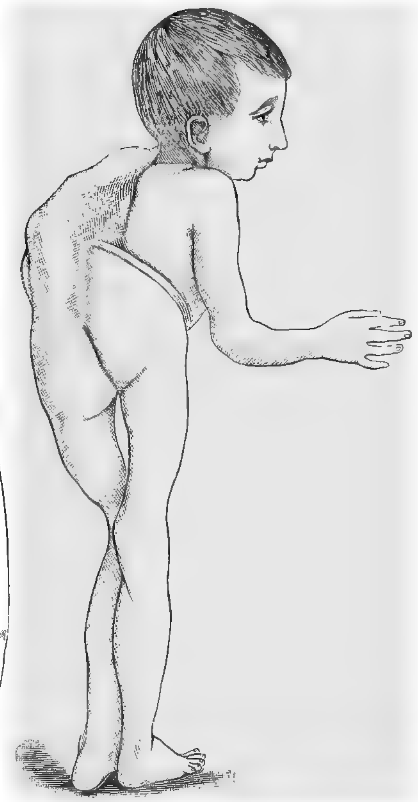
tudes. The rhachitic theory is not a good working theory, because parents themselves are not aware of the presence of rickets, the children are usually treated for disturbances of digestion and various minor ills, while the physician himself dislikes to apply the term "rickets" to cases occurring in children in the better walks of life. The parents, therefore, become aware only after the deformity has developed that the child has passed through the rhachitic stage.

While predisposing causes are so uncertain, it behooves us to look for exciting causes. Among these may be mentioned faulty attitudes at school

FIG. 301.

A common type of lateral curvature.

FIG. 302.



Lateral curvature from poliomyelitis.

long continued, faulty positions in standing, whether at home or in school. Errors in refraction may lead to lateral curvature, because the child must needs bend forward in order to read or study with any degree of comfort. The occurrence of lateral curvature upon the right side so frequently is due largely, it seems to me, to the increased use of the right side brought about by vocations in general.

A very rare cause of lateral curvature of the spine is myositis ossificans. Fig. 300 is a case that was for many years under my observation, and I had an opportunity of observing the case through its different

stages. Poliomyelitis is a not infrequent cause of lateral curvature. It occurs not so much from paralysis of the muscles of the body as from paralysis of the muscles of the extremities. For instance: a deltoid paralysis will give rise to a curvature on the opposite side. Crural asymmetry of any kind will often produce a lumbar curve, while the extreme loss of power that is associated with a dangle-leg often results in a moderate grade of spinal curvature. Indeed, the case which is represented in Fig. 302 is of this type. And, last but not least, crural asymmetry is the most frequent cause of lumbar curve.

Pathology.—The pathology is well understood. It is a lack of symmetry between the two sides of the vertebræ, a rotation of the vertebræ upon the vertical axis, a wedge-shaped condition of the vertebræ, a bending of the ribs near the spinal articulations, besides numerous changes in the thoracic walls and cavity. The involvement of the spinal cord or the meninges is exceedingly rare, yet there are on record cases showing disturbances of muscular nutrition, various forms of neuralgia, and even paraparesis, clearly dependent upon the pressure on the cord, and especially on the nerves at the foramina of exit. A true ostitis is rarely present, and when it is present it is confined to the edges of the vertebræ or the lateral masses, and is secondary to, or dependent upon, the pressure of these parts one upon the other by reason of the distortion and the shortening of muscular tissue. The text-books are so replete with illustrations of the scoliotic spine that I have refrained from presenting the customary figures.

Clinical History.—The changes that lead up to a well-marked rotary curvature of the spine are so insignificant and so very slight that one seldom encounters a case in what is known as the very early stage. The attention is generally first called to the deformity by the dressmaker or by the mother herself when she is fitting garments, and attention is then called either to what is known as the "angel-wing" or to the high hip. By "angel-wing" is understood the undue prominence of one scapula. The lower angle is on a plane much posterior to the lower angle of the other scapula. The body of the scapula is raised from the chest-walls apparently, so that the vertical plane of the body itself is posterior to the vertical plane of the body of the other scapula. By the high hip is understood the prominence of one iliac crest over that of the other. This is due to obliquity of the pelvis, and associated with the high hip is a deep ilio-costal space. The prominent scapula is associated with the earliest stages of a lateral curvature. It is true that to detect the prominence of this bone an observant eye is often called into requisition; but rotation of the vertebræ cannot take place without a projection of the ribs on the convex side and a depression of the ribs on the concave side. This projection will, of necessity cause change in the appearance of the scapula. Long before any actual lateral deviation occurs the rotary element is present, and the lateral deviation appears as the rotation becomes more pronounced. Next in order of frequency we have a lack of symmetry between the tips of the shoulders. One is a little higher than the other. The acromion process is on a plane anterior to the acromion process of the other side. Among other signs we have a lack of symmetry between the ilio-costal spaces—the one is rather deep, the other long; the actual deviation, with a compensatory devia-

tion on the opposite side, the curve resembling a letter S; the recession of the chest-walls on the concave side, with a tilting of the lower angle of the scapula toward the vertical line; an unequal mammary development; a narrowing of the chest-walls anteriorly; and often an obliquity of the pelvis. The pigeon-breast or "bird's-nest" deformity is frequently associated with lateral curvature, and their presence rather confirms the rhachitic origin of the distortion. As the deformity increases from month to month, or sometimes from year to year, the patient is shortened in stature; the angel-wing becomes more prominent; the ribs on that side, in fact, form an enormous bosse known as hunchback; the axilla on the concave side approaches quite closely the iliac crest; the free ribs are unduly prominent; and the patient has a very awkward gait. In Fig. 301 we have a lateral curvature, with the spinous processes dotted in order to bring out in more prominent relief the actual lateral deviation and the letter S curve. In order to represent an extreme degree of lateral curvature I have introduced Fig. 302. This occurred in a child with poliomyelitis, and the extreme distortion here noted is largely dependent upon the paralysis which developed in early life.

Diagnosis.—In the deformity now under consideration early diagnosis is quite as important as in any deformity within the range of orthopædic surgery. Lateral curvature which is well advanced does not require any special skill in diagnosis, and it is only necessary to note the characteristics of a lateral curvature to differentiate this from the deformity of Pott's disease, or from round shoulders, or rhachitic kyphosis, or irritable spine. An early diagnosis presupposes a knowledge of the normal positions of the scapulæ, the symmetry of the chest-walls, the symmetry of the iliac crests, and the normal anatomy of the spinal column itself.

A routine examination is the first step in diagnosis, and the points for observation are the following: The relationship of the scapulæ one to the other; observe whether they are symmetrical; observe the iliocostal spaces; note whether one is deeper than the other or one longer than the other; note the position of the tips of the shoulders, the acromion processes; then have the patient bend forward at the hips, knees perfectly straight, and note whether the chest-walls on one side are more prominent than those on the other; note the prominence or recession of the transverse processes; dot the spinous processes, and let a plumb-line fall from the vertebra prominens, and draw a line with a dermatograph or pen along the line—the slightest deviation can, in this way, be detected; learn the habitual attitude of the patient. In making a differential diagnosis one must distinguish between a slight rotary curvature and an irritable spine. In irritable spine we have intercostal neuralgia, tenderness along the spinous processes, and especially on either side of the spinous processes. This condition is so closely allied to hysterical spine that tenderness on pressure may be found at various bony points. From round shoulders the diagnosis can be made by the tests above given.

Treatment.—No hard-and-fast rules can be formulated for the treatment of lateral curvature. The ideal treatment is properly supervised medical gymnastics. The use of apparatus is occasionally called for, an out-of-door life with the tonic effects of a bracing atmosphere, regular

hours for eating and sleeping; in other words, a good hygiene enters largely into the therapeutic formulary for lateral curvature. It is difficult to determine always just how much exercise a child shall take or how the exercise shall be taken. Suffice it to say that any exercises which are prescribed ought to be not only taught, but insisted upon.

For convenience curvature may be divided into three classes: (1) the incipient curve, which presents very few changes and a scarcely appreciable deformity; (2) the well-marked curve, associated with the rotation of the vertebræ, prominent scapula, prominent ribs, and unsymmetrical ilio-costal spaces; (3) the exaggerated curvature, with great deformity, an unyielding spinal column—what is known as a rigid column—associated usually with a low grade of muscular development and distortion of the thoracic walls and vertebræ.

In the first class the rule is not to apply any form of apparatus. Even shoulder-braces should be discouraged. Light gymnastic exercises, employed symmetrically, are amply sufficient. The muscles can be very well developed in any gymnasium, provided the patient attend the gymnasium with any specific purpose in view. It is quite essential that the patient should devote more time to athletic pursuits of all kinds than is usually prescribed, and that the hours for study, both at school and at the piano, should be shortened. So far as my own experience goes, the family practitioner has, when these cases have been recognized, been able to afford relief by attention to ordinary hygienic rules. It is well to submit the case to an occasional critical observation, in order that more heroic measures be employed should the deformity belong to the actively progressive kind.

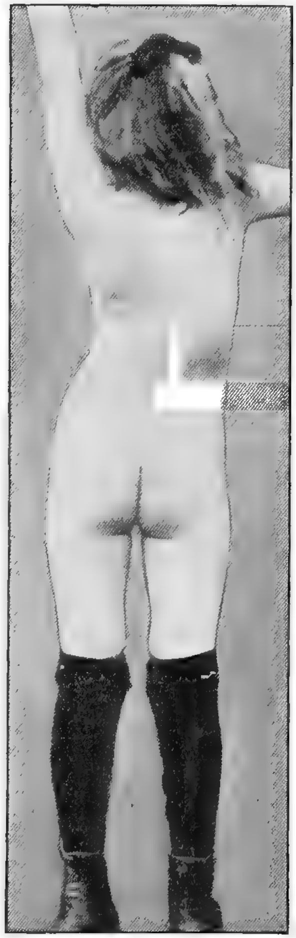
In the second class gymnastic exercises are always desirable, and are to be preferred to any form of apparatus. The exceptions are—stupidity on the part of the patient, and sluggishness and a failure on the part of the parents to appreciate the importance of close attention to details in gymnastic practice. To bring this out in better relief: Given a child who is either too young or too inattentive to learn well a series of exercises, it is useless to follow this course longer than one or two months: we must supplement the exercises with an appliance of some kind; and for the average practitioner there is nothing quite so good as the plaster-of-Paris corset, worn the greater part of the day, taken off toward evening, and dispensed with until the following morning. Again, some children, although old enough to appreciate the advantages of this treatment, seem to lack gray matter. They are stupid, dull; they fail to study at school—fail to apply themselves at anything which requires any effort or a reasonable amount of intelligence. The combination of exercises with apparatus is not generally regarded as the best form of treatment, yet there are some very good orthopædic surgeons who not only combine apparatus with active exercises, but devote a good deal of personal attention to forcible movements, day by day, with the idea of correcting the rotary element. They admit, as we all do, that apparatus of itself, no matter how skilfully constructed and how accurately applied, fails to untwist; but in the skilled hands of the surgeon an impression can certainly be made upon the rotary element.

It is difficult in a work of this kind to describe the various exercises. My own plan is to follow, as nearly as possible, the list given by Mr.

Bernard Roth of London, and to supplement these with forced movements, adding from time to time other exercises as the case seems to demand. A good working list is the following:

(1) *Respiratory.*—Insist upon the patient standing erect. Then, with a dumb-bell grasped in each hand, take a full inspiration with the mouth closed, and hold the breath as long as possible; then open the mouth and gradually exhale. Let this inspiration and expiration be repeated five or six times. With the arms and hands fully extended above the head, still grasping the dumb-bells, repeat the procedure.

Fig. 303.



Key-note position.

(2) *Head Rotation.*—With the dumb-bells grasped tightly, arms by the side, and shoulders well back, rotate the head from side to side to the fullest extent, throwing into the movement all the muscular force that is possible. Do this from fifteen to twenty times. Let the patient count aloud every one of these rotations of the head.

(3) *Lateral Flexion of the Head.*—Same position as in 2, with the head rolled vigorously from side to side toward the shoulders, counting as above.

(4) *Circumduction of Arms.*—With forearms extended, dumb-bells well grasped, make as complete circumduction as is possible with the arms from the shoulders. From ten to twenty times will be sufficient.

(5) *Pugilistic.*—This is a mere arbitrary name for this exercise, which is done as follows: The patient standing erect, shoulders well back, forearms extended on the arms, extend both arms forward at a right angle with the body, palm upward; clinch the bells tightly, then flex the forearm vigorously on arm, while the arm falls to the side and is even forced backward, then extend; flex the forearm as before; extend the arm from the side with palm upward; bring the whole arm, with forearm fully extended, down forcibly against the side. This exercise may be repeated from seven to ten times.

(6) *Key-note.*—With dumb-bells grasped tightly extend the arm and forearm of the concave side well above the head, and the other arm and forearm extended laterally from the side at a right angle with the body. Now let the patient, with arms in the position just described, rotate back and forth to the fullest extent the upraised arm, counting one for a complete revolution. Repeat this ten times. (See Fig. 303.)

(7) *Four Count.*—With dumb-bells, bring the arm forward from the side of the body to a right angle, forearms fully extended, palms facing;

throw the arms well back, and then strike the ends of the dumb-bells briskly against each other back of the hips. As they rebound strike the second time. Repeat this movement from eight to ten times.

(8) *Anvil Stroke.*—Starting in the same position as above, bring the arms back of the body with forearms fully extended, and by a rotary movement of the shoulders strike the dumb-bells together, first one end, then the other. This should be done from ten to twenty times.

Additional exercises may be added to those just given, and resistance may be offered in a variety of ways. Heavy dumb-bells may be lifted from the floor and carried to the extreme point above the head. Exercises may be given to the lower limbs with the patient lying both prone and supine on a table. Indeed, the surgeon can devise a variety of means which will tend to correct the curvature and at the same time bring out in full development the muscles which seem to be weak. It must be remembered that all exercises should be light and infrequent at first, that heavier weights should be used as the muscles develop, and that adequate periods of rest should be insisted upon, both while the patient is drilling under the eye of the surgeon and under the eye of the mother or nurse at home. From a half hour to an hour a day is little enough to devote to these exercises. After they have been well learned they should be continued every day for from one to two or three years.

Self-suspension in the swing has not had the reputation of effecting much relief. A very fair illustration of the improved position is shown in Figs. 304 and 305.

My aim in outlining a course of exercises has been to present such as any surgeon or physician can employ in his own office and without the aid of various appliances for forcible correction. The apparatus of Hoffa, the bars of Lorenz, and the usual devices employed in a gymnasium have not been presented, because they are not only difficult to keep in order, but because the results obtained from these devices have not been sufficiently gratifying to enable me to urge them upon the consideration of the readers of this article. The management of a case of lateral curvature in a well-to-do family is sufficiently easy, for the reason that the time can be given for treatment—the families themselves are interested in the improvement noted; but among the poor and the shiftless the management of such cases is exceedingly difficult. Among this class may be noted working-girls, whose time is taken up throughout the entire day, and who are really too much worn out to drill or practise in the evening. At the Hospital for the Ruptured and Crippled attempts are being made from time to time to treat the school-girls among the poorer classes, and, while much is being accomplished, it is very difficult to carry out any form of treatment to a satisfactory issue.

In estimating the amount of relief afforded, the scoliosometer, employed at long intervals, may be advised, but the ideal instrument is yet to be devised; and, after all, one relies more on his own observations carefully made at stated intervals, and on the reports that come from the mother, the teachers, or the dressmaker. Such reports as the following are very suggestive. From the dressmaker, for instance: "Less padding is required. It is easier to fit the dresses." From the mother

or nurse: "The girl holds herself in much better position. It is no longer necessary to insist upon her holding herself straight," etc. etc.

In the treatment of the third class the plaster-of-Paris jacket and the various forms of steel braces are really necessary to prevent a further increase in the deformity. Illustrations of the various braces are omitted, for the reason that no one is universally recommended, and the claims for any one in particular are that it simply prevents increase in deformity. The advocates of mechanical devices usually supplement with gymnastic exercises and forced movements. In my own hands the solid plaster-of-Paris jacket applied at intervals of from two to three months, and applied with the patient self-suspended to the utmost limit and under a great amount of lateral pressure, has yielded the best results. In a number of instances I have been enabled to convert an old rigid curve into a flexible curve, and have been enabled, after from six to

Fig. 304.

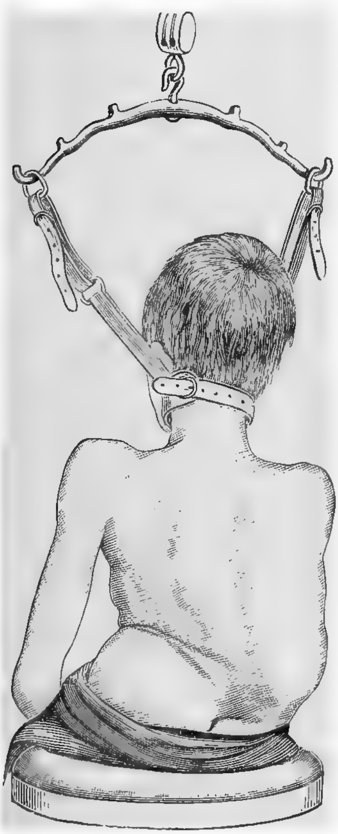


Fig. 305.

Self-suspension in the swing.

eight months of this kind of treatment, to employ the medical gymnastics as above described.

Club-foot.

Varieties.—By "club-foot" is meant a deformity of the foot, either congenital or acquired, involving extension, flexion, inversion, eversion, or rotation. Extension and inversion are usually associated, and less frequently still extreme flexion. The synonyms are Talipes and Reel-foot. The German name is Klumpfuss; the Latin, Pes contortus; the French, Pied bot. The term *talipes* is generic, and the various modifications are talipes varus, valgus, equinus, and calcaneus.

Varus may be described as an elevation of the inner border of the foot, with the sole turned inward, while the anterior portion is adducted. The patient stands on the outer border and upper aspect of the foot. Valgus is directly the opposite to this, and is an exaggerated form of flat-foot. Equinus is an elevation of the heel, so that the weight is borne on the toes and ball of the foot. Calcaneus is just the reverse: the front of the foot from the arch to the toes is raised from the floor, the tendo Achillis is much elongated, and the weight is borne altogether upon the heel. For purposes of memory: Varus is an in-turning of the foot, valgus an out-turning; equinus is a raising of the heel, calcaneus

Fig. 306.

Equinus.

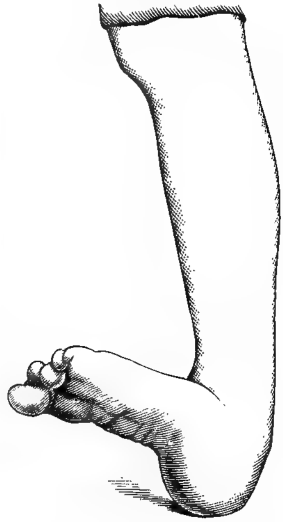
a depression. Talipes equinus is shown in Fig. 306. This is an extreme case, and must not be regarded as a very common one. Both varus and valgus are shown in Fig. 307. Talipes calcaneus is illustrated in Fig. 308. The different varieties thus given are by no means common. It is seldom that one finds a typical form of equinus, varus, valgus, or calcaneus. Yet a typical equinus is not so rare. A form of congenital club-foot that is exceedingly common is equino-varus, and, as will be easily recognized from the name, it is a combination of equinus and varus, the equinus predominating. We occasionally employ the term varo-equinus. This is when the varus predominates. Equino-valgus is a deformity not infrequently met with, and is rarely if ever congenital. Calcaneus is nearly always acquired, and depends, as a rule, upon polio-

myelitis. Another form of talipes which is usually associated with calcaneus is known as cavus, and this is shown very well in Fig. 308. It will be noted that the anterior portion of the foot is slightly flexed in the middle portion, and leaves a transverse furrow in the sole, just back

Fig. 307.

Varus and valgus.

Fig. 308.



Calcaneus associated with cavus.

of the ball of the foot. It is well to state that a cavus is not always associated with a calcaneus, but is sometimes seen in mild cases of equino-varus. The transverse furrow which is characteristic of the cavus is nearer the heel than in that form of cavus associated with calcaneus. A form of club-foot which has been described by Shaffer of New York is known as non-deforming club-foot. This is simply a very mild grade of equinus, or, as it has been described, a mild form of club-foot, with the elements of the deformity present, but the deformity itself absent.

Etiology.—We have two forms, etiologically speaking, the congenital and acquired. By congenital of course it is understood that the deformity is noted at birth, and by acquired, that it has occurred subsequent to birth. Equino-varus is nearly always congenital, calcaneus rarely ever congenital, valgus is rarely congenital. The acquired forms, then, are calcaneus, equinus, valgus, and cavus.

When we say that a deformity is congenital, we simply state an observation made at birth. Dr. W. R. Townsend has very carefully analyzed 2386 cases of club-foot under observation at the Hospital for the Ruptured and Crippled. His paper is published in the *Transactions of the Medical Society of the State of New York*, 1890. The results of this analysis are summed up as follows:

"Club-foot among most frequent of congenital deformities; congenital club-foot less frequent than non-congenital; males more often affected than females.

"Equino-varus the most frequent deformity, constituting about three-quarters of all the cases.

"Both feet more often affected than one.

"Right foot more often affected than the left.

"Non-congenital club-foot most frequently due to paralysis.

"The paralytic forms usually due to poliomyelitis.

"One foot more often affected than both.

"Flat-foot more commonly affects both feet.

"Males and females about equally affected in non-congenital club-foot.

"Equino-varus, equinus, and calcaneus most common forms of paralytic club-foot.

"When both feet are affected, the deformity is usually the same on each foot.

"Equinus and calcaneus are rare as congenital deformities, but common as paralytic."

The cause of congenital club-foot is still enveloped in more or less obscurity. Various theories have from time to time been propounded, and these theories have been stoutly maintained by their various advocates. It has been sufficiently proven, in the opinion of the writer, that paralysis is not a cause of congenital club-foot. The best working theory is that first propounded by Essericht of Copenhagen, later elaborated by Berg of New York and Parker of London. (See page 267.) After all, it is not a theory a thorough understanding of which will enable one to prevent the occurrence of club-foot, because all the changes are occult, and because there is nothing during the development of the fœtus which can be recognized by the physician or surgeon. Just how maternal impressions may produce an obstruction to rotation we are at a loss to understand. Suffice it to say, that maternal impressions are beyond our control as a rule, and as yet we have no means of preventing a congenital deformity or arrest of development.

We are much more familiar with the causes which produce acquired talipes. One of the most frequent is a poliomyelitis anterior. In this disease of the spinal cord we have, as a result, more or less complete paralysis of the gastrocnemius, which gives us calcaneus; of the anterior tibials, which gives us equinus; of the anterior tibials and the peroneals, which gives us equino-varus; of the interossei, which gives us cavus: and of the posterior tibials and the anterior tibials, which gives us valgus and equino-valgus. Injuries to the foot, such as unrecognized and untreated sprains, sometimes result in talipes. Disease of the tarsal and metatarsal bones results quite frequently in talipes. Any compression of the foot may produce talipes. The treatment of the Chinese foot invariably produces a high degree of cavus. Injuries about the leg involving either the bone or soft parts result occasionally in a form of club-foot.

Pathology.—The pathological changes involve the bones, the ligaments, tendons, and muscles. Where the tendons and muscles are alone involved, the changes are of little consequence and correction of the deformity is easily accomplished. This rule hardly applies to the congenital forms of club-foot, because the muscular and tendinous changes have occurred during fœtal life, and before treatment can be begun already the ligaments and bones, or at least the elements of bone, have been so

altered in shape that at birth we have changes involving all the structures in the foot. Without going into too elaborate detail, it may be stated that the scaphoid is altered in shape and its facets are changed. The bone itself becomes smaller, the cuboid becomes larger and more wedge-shaped. The facets on the head of the astragalus are changed to accommodate the adjoining bones in their displaced positions. The os calcis is elongated in its anterior portions. The deltoid ligament is shortened, the outer ligaments are lengthened. The plantar fascia is shortened. The structures in this locality are also shortened. The tendons on the outer side are elongated, and as growth goes on these changes become more marked. The pathology of an acquired club-foot is very similar to that of congenital, except that the bony changes are never so pronounced. An explanation of this can be had in the ossification of certain bones before the occurrence of the lesion which produces the deformity.

Diagnosis.—There is so little in the clinical history that the usual paragraph is omitted, and, indeed, there is so little to diagnose that we might well omit this, for the reason that a knowledge of the varieties of club-foot is sufficient to enable one to recognize the deformity. It may be desirable, however, to call attention to points in differential diagnosis between club-foot and weak ankles.

A young child may have a specially long tendo Achillis or much laxity about the ligaments of the ankle, and the foot can be brought into marked calcaneus. One is consulted occasionally about a deformity of this kind, and it is only necessary to compare the measurements of the calves and to test the functions of the muscles to eliminate any genuine calcaneus. Again, when the child begins to walk a pseudo-equinus is observe. The child does not get the heel to the floor well—prefers to walk on the toes and balls of the feet. This is a source of alarm to the parents, and advice is frequently sought. It needs only careful examination to eliminate any equinus. If the foot can be flexed passively beyond 90°, there is no equinus. Rhachitic children present often weak ankles. Some look upon this weakness of the ankle as genuine valgus, but the deformity is so easily corrected by slight pressure from the finger or thumb that club-foot is easily excluded. In children of older growth, and even in patients who are adolescent, there is often a slight equinus depending upon an old poliomyelitis, with very slight paralysis. By comparing the calf measurements and by testing the functions of the foot actively and passively one can readily decide upon the shortening or not of the tendo Achillis.

The grosser forms of club-foot are so easily recognized, and so easily understood, that further discussion of the subject is unnecessary.

Treatment.—This may be divided into manual, mechanical, and operative.

Manual Treatment.—By manual treatment is meant the attempted correction of deformity by the use of the surgeon's hand or the hand of the masseur, the nurse, or the mother even. It not infrequently happens that the monthly nurse is competent to correct a mild grade of club-foot if recognized by the accoucheur. Whether she succeeds or not, it is at least an important preliminary step to the other forms of treatment. While the bones are still unformed and while ossification is as

yet rudimentary, a great deal can be done by the intelligent handling of a club-foot although the deformity be of the highest grade. The frequency with which the baby must be handled makes the manual treatment quite practicable. The plan simply is to grasp the front of the foot with the hand and untwist, making extension and eversion, subsequently flexion of the foot, rubbing the parts on tension with the fingers and thumb of the other hand. The stretching can be made rather sharp, and then the force be loosened, the foot being held for a half hour or longer in a corrected position. I am sure that sufficient attention has not been given to this important branch of treatment, and I need not apologize for calling attention to it now. Manual treatment can be begun, therefore, at birth, and continued up to the second or third month without compromising in the least any subsequent mechanical treatment. If such measures can be employed intelligently and faithfully, then the mechanical treatment can well be postponed until the third or fourth month. The question which is so often asked, When shall the treatment of club-foot be begun? may be answered as above.

Mechanical Treatment.—By this is meant the gradual or instantaneous correction of the deformity by means of apparatus; in fact, by splints of any kind. Even in the adjusting of an apparatus a great deal of manual dexterity is required. The foot, for instance, can be held by the hand in an excellent position while an unyielding apparatus is adjusted; for instance, the application of a straight splint in the shape of a bit of cigar-box or steel to the outer side of the limb from the head of the fibula down past the external malleolus to the toes, the equino-varus having been converted by manipulation into pure equinus. In the judgment of the writer it is very important to correct—and indeed, over-correct—the varus before any attention is given to the equinus, for the reason that the correction of equinus is very simple, and the more pronounced the deformity, the easier the correction; but this is not true of varus. A much longer time is required, whether one employs a splint with screw for daily stretching, or whether one employs manual force once a week or once in a fortnight and holds the foot in good position by plaster of Paris. The important feature, therefore, is to over-correct the varus before any attention is given to the correction of the equinus. In the new-born this is by all means the best plan to pursue, and in older children where relapse has occurred the correction of the varus first is very nearly as important.

Among the appliances for mechanical treatment may be mentioned in the order of availability the following: The straight splint made from a bit of cigar-box or from bar steel; plaster of Paris; the club-foot shoe of Hugh Owen Thomas, which consists of a single bar of steel to pass from the calf to the sole of the foot, and bent at the heel at an exaggerated right angle, the ends attached to a piece of sheet steel, one of which shall partly encircle the calf, the other partly encircle the ball of the foot; the Knight club-foot shoe, the Taylor, the Shaffer. The old-fashioned Scarpa's shoe is not employed by orthopædic surgeons, so far as I know, but is frequently supplied by the instrument-maker when order is given in general for a club-foot shoe.

The straight splint can be made available by any practitioner. The board needs to be padded well and the padding held in place by a com-

mon flannel bandage. One end is fastened to the calf by a broad band of adhesive plaster; a pad is placed just above the malleolus while the varus is converted into equinus, and the lower end of the splint is fastened by adhesive plaster, with the ball of the foot well padded to the end of the foot. In obstinate cases, where the varus cannot be immediately converted without an anæsthetic into a pure equinus, rather broad bar steel, padded well, can be made use of to great advantage, because one can shape it to the deformity in its different stages. These steel bars can also be used for the correction of equinus, and in a number of instances I have myself completely corrected both the varus and the equinus without an anæsthetic, without any operation, but by simply shaping the bar steel from time to time to the position gained by manual force. When it is necessary to over-correct the varus at once, it is best to give an anæsthetic, and my preference is for ether to the primary stage. The foot can then, during the few moments that the anæsthesia is complete, be forcibly brought into the over-corrected position and held while the splint or plaster of Paris is applied. To prevent the splint, if the steel bar be used, from slipping, an adhesive strip or two should be applied in the upper and lower portions, after which a roller bandage from the toes to the knee will secure the good position obtained. From two to four weeks later the equinus can be corrected by a division of the tendo Achillis, under primary anæsthesia preferably, otherwise without an anæsthetic, and the equinus converted into a calcaneus. The curved steel bar applied posteriorly or the plaster-of-Paris bandage may be employed at this operation, and the foot held in position for from two to four weeks, according to the amount of time at one's disposal.

The further treatment of the case, whether the deformity shall have been corrected rapidly or slowly, should be continued by the use of the Knight club-foot shoe, which may be described as follows: A foot-plate of steel, the shape of the foot; an upright counter of steel which shall pass from one malleolus under the foot-plate to the other malleolus; a heel-cup of leather which shall pass from this steel counter from one side to the other; a steel spring on the outer side extending from a joint at the ankle, and on the outer portion of the steel counter, up to a calf-band, which shall be of sheet steel about one inch in width, and encircling the upper portion of the calf two-thirds of its extent; the remainder completed by a band of leather, which lines the steel calf-band and is buttoned or buckled to the upper end of the upright bar. The whole appliance, thus completed in the rough, should be lined with kid or shaved sheep. The heel can be secured by means of an instep-strap, which consists of a padded triangular piece of soft leather to the end of which long tapes are sewn. These tapes pass next the foot and back of the steel counters and up over the outer sides to tie over said triangular pad.

To apply the apparatus, then, the foot can be placed on the plate with the heel back well into the heel-cup and between the steel counters, a stocking over the foot if desirable. The instep-strap is then applied so as to hold the heel well into the cup. Finally, the steel upright and calf-band can be brought into position. The joint at the ankle should be a simple hinge-joint with a steel peg just below the rivet and in front of the

distal end of the steel upright. We can thus hold the foot at a right angle with the leg, or, if it is necessary to increase the angle—that is, to make it more acute—the steel peg just referred to can be set farther back.

After the Knight club-foot shoe has been thus adjusted, if the toes incline to eversion and overlapping at the inner border of the plate, a lip can be riveted to the plate, or the plate in the first instance can be cut so that the lip can be turned up, and thus make pressure against the foot immediately back of the ball of the great toe. This lip need not be more than a half inch in height, or even less than this. If a leather shoe is employed at once, there is no need for a roller bandage over the foot to secure it to the plate, but at night this will be a very good precaution to take, for it must be remembered that the club-foot shoe is to be worn night and day—that it is never to be left off longer than just time enough, twice a day, to employ a little domestic massage and manipulation of the foot, the object of which is to over-correct and mould it into a better shape. When these manipulations are made the dorsum of the foot, just over the instep, can be bathed with alcohol and water, half-in-half, or borax-water—anything that will harden the skin. If excoriations occur, then appropriate padding can be employed to prevent further destruction of tissue.

Too much stress cannot be laid upon the necessity for maintenance of the good position obtained by the above procedures. It is easy enough for any surgeon to correct the deformity of club-foot, but it is very difficult for one to maintain the foot in a good position over a period long enough to ensure changes in the facets of the bones, full elongation of shortened ligaments, and the shortening of muscles and tendons on the outer side of the foot. One year is none too long to wear apparatus of the kind just described after the complete correction of the deformity. Certain difficulties will be encountered during the progress of this convalescing treatment which it is well to note:

(1) The child, when it begins to walk, will most surely toe-in or walk pigeon-toed. This objection will be offered by the parents, and the physician himself may feel that it is an objection which should be met very promptly. But let me say that it is not a serious objection by any means—that there is no occasion, as a rule, for apparatus to extend above the knees or to the hips in order that the whole limb may be rotated outward, but have a little device, such as a bit of sole-leather, tacked on to the outer border of the sole from the shank of the shoe around to the inner border of the tip of the sole, and made from a quarter to three-eighths of an inch in height just at the outer border of the tip of the toe. This can be put on by a shoemaker and made so that it will appear neat and inconspicuous. Then the child can be taught to turn the foot out as it walks. This will require a little patience on the part of the mother or nurse, but it will be good drilling.

(2) The heel may not remain in the heel-cup during the entire day or even during the night. Let the parent be instructed to remove the apparatus and secure the heel in good position whenever she finds it slipping up, even if it be a dozen times a day. It may be necessary to assist in holding it in position by means of a figure-of-8 roller bandage. When the heel does slip up, it is a sign that the tendo Achillis is not long

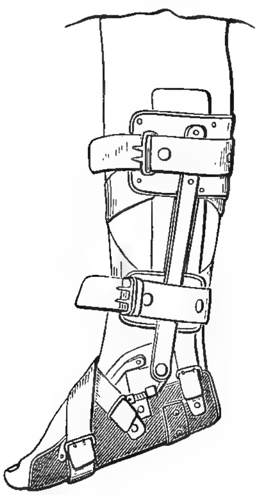
enough, and there may be necessity for further stretching or division of the tendon.

(3) The apparatus may get out of order, and most assuredly will get out of order. The surgeon should fully understand what the object to be attained is, and he should see that the appliance is kept in good repair.

The above remarks on the after-treatment, or the treatment during the convalescing stage, pertain to the management of the case irrespective of the kind of apparatus that has been used or the means that have been employed, operative or otherwise, for the correction of deformity.

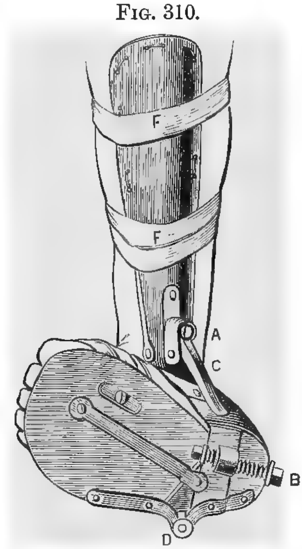
The Thomas club-foot shoe was employed by the late Mr. Thomas with excellent result. This is secured by means of a roller bandage, and can be applied with or without an anæsthetic. It was his custom not

Fig. 309.



Taylor club-foot shoe.

Fig. 310.



Shaffer's modification of Taylor's ankle-brace.

to employ an anæsthetic, but to forcibly flex the foot into good position in spite of the pain produced, and then fasten the foot to his apparatus.

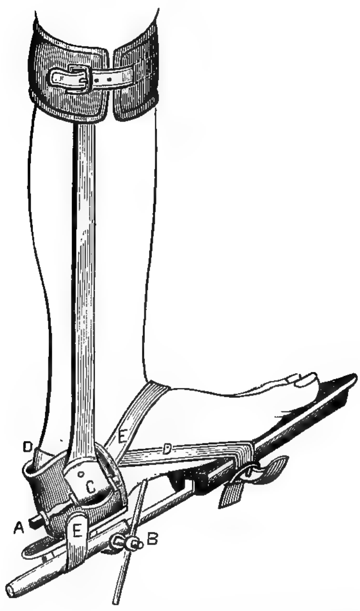
Inasmuch as I have begun with the club-foot shoes, I shall proceed to a consideration of those employed by Taylor and Shaffer, reserving the plaster of Paris for a later paragraph.

The Taylor apparatus is very similar in construction to the Knight, with the exception that the upright bar is on the inner side of the leg, and the foot is pushed out rather than pulled out. The plate is very similar to the plate of the Knight shoe, the lip being on the inner side, instep strapped down to the plate by means of webbing, while a similar stop-joint is employed at the ankle. In some respects this is an improvement on the Knight, especially in those forms of club-foot where one is apt to get excoriations from pressure over the outer side. Indeed, the advocates of the Taylor shoe claim that an excoriation is never produced, and that one can the more readily move the foot into shape by

pushing instead of pulling. Again, the calf-band of the Knight shoe is replaced in the Taylor apparatus by a broad plate on the inner side of the leg, which is laced to the calf and which distributes the pressure over a larger area. An illustration of the Taylor shoe is presented in Fig. 309.

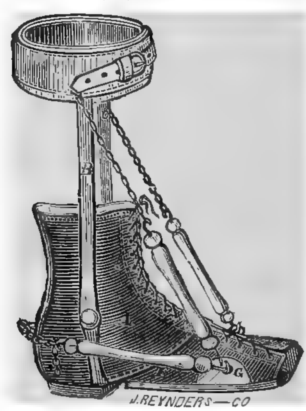
The Shaffer club-foot shoe is a modification of the Taylor shoe, and is shown in Fig. 310. The extension shoe employed by Dr. Shaffer, and one which he has more fully developed, is shown in Fig. 311. The claim that Dr. Shaffer makes for the apparatus he employs is the ability to overcome shortened tissues by means of great force employed by a rack and pinion or an endless screw. The treatment is very efficient in his hands. I have not employed the apparatus to any great extent, because I have found that simpler measures can be used. The Sayre club-foot shoe is shown in Fig. 312. Indeed, I might enumerate a large number of various forms of the club-foot apparatus, all of which in the hands of the inventors certainly accomplish excellent results. The object, however, of the present section on club-foot is to set forth in as much detail as possible the appliances with which I have become familiar, and which, to me, seem all-sufficient. In omitting, therefore, to describe and illustrate the club-foot shoes employed by orthopædic surgeons in general, as well as the surgeon, I do not wish to criticise.

Fig. 311.



Shaffer's extension equinus brace applied, showing action of heel-strap.

Fig. 312.



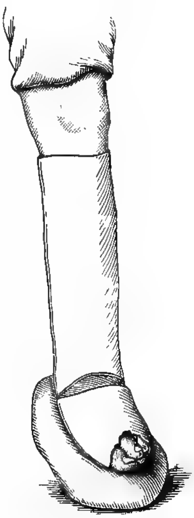
Sayre shoe.

Plaster of Paris as a retentive appliance has already been described in the equino-varus of infancy. It is used to great advantage in the older cases. Indeed, after the deformity is corrected or partially corrected by any of the methods now in vogue there is really no better retentive dressing than plaster of Paris. If one is not familiar with all the details of plaster and has had no experience in its application, then it would be better not to employ this as a retentive dressing, because the

abuses are numerous. For instance: an excoriation produced in a foot whose nutrition is already very poor—and this is more especially true of paralytic forms of club-foot—is most difficult to heal. The average surgeon knows really very little about the use of plaster. It would seem unnecessary to devote any further space to instruction in the use of plaster, because nearly all the text-books on surgery have gone so fully into this subject.

With the Wolff method the profession is not so familiar, and hence it may not be inappropriate to describe the use which Professor Julius Wolff of Berlin makes of plaster in the correction of the deformity of club-foot. After quite an extended use of his method I am convinced that it can be made serviceable in a large number of obstinate cases. The plan is to encase the foot in a snug-fitting plaster-of-Paris bandage from the base of the toes to the upper portion of the calf, the foot, of course, being brought into the best position possible by manual force without an anæsthetic. After twenty-four hours, when the plaster is fully set, a wedge-shaped piece is removed from the outer side of the foot on a line with the mid-tarsal articulation, the wedge beginning just over the head of the astragalus and extending to the middle of the sole of the foot. The width of the wedge should be at its greatest portion, which is over the cuboid, from a half inch to an inch. The section of plaster is to be completed by a simple incision across the inner border of the foot, so that there will be a complete solution of continuity between the plaster which encircles the front of the foot and that which encircles the posterior portion. Now the surgeon may correct the deformity still further by manual force and with very little pain to the patient. While the foot is held in this improved position a fresh plaster-of Paris bandage is bound about the line of section, and the good position is thus maintained. After two or three days the same procedure should be followed, and so on until the varus is completely overcome. In order to overcome the equinus a wedge-shaped portion should occupy the top of the foot over the mid-tarsal joint. An illustration of this form is shown in Fig. 313.

Fig. 313.



Showing the Wolff method.

Thus much for the treatment by means of apparatus, but apparatus must play an important part in the after-treatment of nearly all the operations that are employed for the relief of club-foot. It is true that the surgeon claims to perform operations that will do away with the necessity for apparatus of any kind, but, so far as my own experience goes, even the most approved operations, as a rule, require some sort of mechanical contrivance to maintain the good result obtained. The operations are—(1) Manual correction under an anæsthetic; (2) The employment of mechanical force under an anæsthetic, such as the tarsoclast of Bradford, the Thomas wrench, the Phelps machine, etc. etc.; (3) The subcutaneous tenotomy and myotomy, coupled usually with the employment of manual or mechanical force; (4) The open section, with division of all the soft parts until with manual force the deformity can be corrected; (5) The

bone-operations on the foot, such as removal of the astragalus, cuneiform osteotomy, and linear osteotomies.

The employment of manual, or even mechanical, force under an anæsthetic is often justified, and indeed is a very excellent method to employ where time is an essential element. In very young infants the varus may be completely overcome at a single sitting, and retentive appliances can be worn for two or three weeks, while the equinus can be very nearly overcome at another sitting, and completed at still a third. The simplicity of the tenotomy and myotomy appeal, however, to the surgeon, and so much can be accomplished by these procedures that manual or mechanical force is usually supplemented by tenotomy or myotomy, or both.

There is a growing disposition among surgeons to make light of subcutaneous tenotomy and to advocate division of tendons through an open wound. Indeed, some surgeons go so far as to relegate subcutaneous surgery to the Middle Ages. The chief reason for such a statement is that in rare instances aneurysms are reported to have resulted from subcutaneous tenotomies. The freedom with which sections of various tissues can be made under the present aseptic system has led certain orthopædic surgeons to cut recklessly. Now, if an orthopædic surgeon injures a blood-vessel while attempting to divide the tendo Achillis, for instance, it is not the fault of the operation, but it is because he has not familiarized himself with the simple details of so valuable a procedure, or it may be because he has grown reckless or careless by reason of his long service; and certainly this is no excuse for an accident of that kind. The rules for dividing tendons are so simple that they ought to become familiar to every student. The principal rule is to map out the tendon with one's finger, to refresh one's anatomy a little, and then insert the tenotome through the skin and behind the tendon. One does not need to divide all the tissues in the neighborhood of the tendon. Take the peroneal tendons, for instance, or the tendons of the tibialis posticus or tight bands of plantar fascia. These can be all sufficiently brought out by a little manipulation, so that their division subcutaneously can be easily accomplished. Any student, therefore, can be taught to divide a tendon subcutaneously with perfect safety, but any student cannot be taught to divide a tendon through an open wound and get the result which an accomplished surgeon in a well-appointed operating-room can in the majority of instances obtain. Another advantage which subcutaneous tenotomy possesses is that the operation can be done frequently without an anæsthetic and in one's office. Indeed, the operation can be done almost as soon as suggested. The mother will very often submit to a proposition of this kind with infinitely more alacrity than she will to a procedure which necessitates the use of ether or chloroform and an open wound. One important lesson to learn in any of these subcutaneous operations is to over-correct immediately, and not wait for a certain number of days to begin the correction of the deformity. A few simple details as to dressing may not be inappropriate in this connection, and they are as follows: Employ a bit of protective or adhesive strip to cover the punctured wound made by the tenotome; avoid crowding any pads or dressing between the ends of the divided tendon, but so adjust any aseptic or other dressings that no pressure will come over the skin

which lies between the ends of the tendon; take special care to protect the instep well, especially where the foot is brought up in sharp dorso-flexion, and in this way constriction of the parts will not occur.

The treatment by open section has received a powerful impetus by the labors of Dr. A. M. Phelps of New York. He has sufficiently demonstrated that a large section can be made in the sole of the foot and through the inner border; that the deformity can be in this way corrected; that the open space will fill in with blood-clot, which will become organized. In cases where tenotomy and myotomy fail, where resort to violent force under an anæsthetic fails, the open method offers the next step in operative procedures, and will be all that is necessary for a large proportion of very obstinate cases. Even this operation is occasionally supplemented by removal of bone on the upper and outer aspects of the foot.

This brings us to the question of osteotomy, whether cuneiform or linear. The cuneiform osteotomy is an operation that has long prevailed, and that will probably remain as a serviceable method in certain obstinate cases. The special kind of cuneiform osteotomy must largely remain a matter of choice with the individual surgeon. That of Davy is most commonly employed, and consists of a wedge-shaped section through the outer side of the foot, involving the cuboid, part of the

Fig. 314.

Club-foot treated by tenotomy and manual force.

scaphoid, the neck of the astragalus, and portions of the cuneiform bones. One who begins an operation with the idea of sacrificing the smallest amount of bone-tissues rarely completes the procedure of Davy, but finds it possible to correct, and even over-correct, without so much loss of bone-substance. A linear osteotomy through the neck of the os calcis is sometimes all that is necessary. The removal of the head of the astragalus will often enable one, with the section through the soft parts, to get all that is desired. An operation which has much to commend it in my judgment is removal of the astragalus. After all, one who has had a long

experience in the management of club-foot finds that these major operations are seldom called for, and that he can correct the most obstinate cases without resort to such extreme measures. For instance, a case represented in Fig. 313 was cured without any bone-operation, but simply manual force under an anæsthetic from time to time, a tenotomy or so, and the employment of the Wolff method. Take, again, Fig. 314. This patient was never subjected to any severe operation, and he was cured many years ago. Quite recently I find that he has followed the occupation of butcher.

The Less-frequent Forms of Club-foot, such as Calcaneus, Valgus, Cavus, Pes Planus.

Calcaneus.

For calcaneus we rely upon both mechanical and operative measures. The aim is to relieve traction on the tendo Achillis. To this end devices are employed which keep the foot extended. A simple strap of webbing from the back of the heel up to a calf-band which partly encircles the calf, held in place by a strap, is very simple, and so long as the strap is efficient the extended position of the foot can be maintained. The braces employed are such as have a reverse catch at the ankle-joint—that is, the ordinary form of club-foot shoe which has already been described—with a rivet or peg back of the lower end of the upright and just below the joint. Simple as this appears, it must really be a very heavy apparatus to meet the indications, because all the weight of the body is borne upon the ball of the foot, and this weight is transmitted to the shin-bone, upper portion. As a result, the foot-plates break very frequently, the peg which makes the reverse catch wears off soon, and for that reason a more complex joint is required, and one, as above stated, quite heavy. Where a shoe is employed and where the brace is attached to the shank, a very heavy steel plate needs to be inserted in the sole and specially reinforced throughout the shank. In very young children, where it is not so important that they should walk (and the misfortune of this is that the calcaneus usually occurs after the second year of life and as a result of poliomyelitis), plaster of Paris or water-glass bandage may be employed. The heel of the shoe can be raised quite high and made wedge-shaped, so that the weight will be distributed between the ball and the heel. My own experience, I am sure, coincides with that of most orthopædic surgeons, and it is this: there is really very little to be expected in the way of cure. The apparatus is worn for years usually, and finally the patients get tired of it, and prefer to let the shoe get ill-shapen, and wear the heel off as they walk.

The operation that has been most successful in my hands, and that is really an old procedure, is the shortening of the tendo Achillis by removal of a portion and suturing the tendon, or by an oblique section of tendon with free overlapping, the parts held in place by strong sutures which are long undergoing absorption, such as silkworm gut, or kangaroo tendon preferably. Wire is sometimes used, but this is not a very reliable agent, as the irritation that follows from the moving up

and down of the tendon causes sometimes suppuration, and finally the wire is exfoliated. Many attempts have been made to get a satisfactory operation of this kind, but the operation which has yielded me the best results is that known as the Willet, after Mr. Willet of St. Bartholomew's Hospital. This consists of a pretty free section of the parts, full exposure of the tendo Achillis through a Y-shaped incision, the firm suturing of the divided tendon, and secondarily a suture of the tendon to the soft parts as well. The whole operation, when completed, gives a very strong mass, which, under a good deal of after-protection, holds fairly well. About 50 per cent. of the cases upon which I have operated have remained cured after four or five years. One of the difficulties is that the calcaneus is rarely ever pure and simple, but it is associated with a paralysis of the peroneals or the posterior tibials, or even the anterior tibials, and in addition to the calcaneus we have a flail-foot. The operation is certainly justifiable, and in the hands of one who has had a very large experience in work of this kind an excellent result may, as a rule, be predicted. A very good illustration of this deformity may be recognized in Fig. 308. The apparatus to be employed after the plaster of Paris is discontinued is a rude contrivance, yet serves a very good purpose. A shoe can be applied over it, and the principle involved is that we have an unyielding tongue to the shoe. The apparatus, with shoe applied, is shown in Fig. 315.

Fig. 315.

Shoe for calcaneus.

Valgus.

Talipes valgus is treated best by some form of apparatus, and where there is an equinus complicating the tendo Achillis should first be either stretched or divided, so that this element of deformity can be eliminated. In milder cases of valgus a spring of some kind may be inserted within the shoe, such as the Whitman spring for flat-foot, or the shoe itself may be built up on a last with high arch and the shank reinforced by steel. But, after all, it is necessary in the majority of cases to have a leather pad attached to the inner plate of the ordinary ankle-supporter, which leather pad shall pass over the inner side of the foot and be secured to the bar which passes up on the outer side. In milder cases, too, the sole of the shoe may be raised along the inner border from the end of the heel to the tip of the toe. Say, have this whole border from a quarter to a half inch higher than the border on the outer side. A fair illustration of valgus may be seen in Fig. 307.

Cavus.

In the management of talipes cavus the principles are not very complex. One needs only to employ a plate on which the foot can be well

strapped, bringing what pressure can be borne over the instep. In proportion to the pressure that can be borne, just in that proportion will the deformity yield; but where there are tense bands of plantar fascia it is just as well to divide these subcutaneously and at the same time break down the high arch under an anæsthetic. The neat-fitting plaster-of-Paris bandage for two or three weeks after the production of so severe a sprain is, as one would suppose, called for. Then an apparatus worn for a few months will succeed in effecting a cure.

Pes Planus, or Flat-foot.

This deformity is either atonic or spasmodic. By the term "atonic" is meant a flat-foot which is dependent upon weakness of the ankles, which weakness has no reference to paralysis, but is simply a lax condition without any spasm and occurring in children or in adolescents. The atonic may also be due to paralysis from poliomyelitis or from a cerebral lesion. The spasmodic form is known usually as painful flat-foot, and is associated with more or less spasm of the muscles. This spasm seems to be brought about by a dropping of the arch of the foot, due to changes in the articular facets of the bones that go to make up the arch of the foot, and thus an irritation is produced. We have all grades of flat-foot, from a very slight dropping of the arch to a complete dislocation of the bones of the mid-tarsal region. The scaphoid may be so prominent that the hollow of the foot will really "make a hole in the ground." In such cases there is a depression on the outer side. The walking is very painful, and there is abduction of the foot, with subluxation forward and downward of the head of the astragalus.

Pathology.—The pathology of flat-foot has been so fully presented within the last few years that it is needless to discuss the subject at length in this connection.

Diagnosis.—The diagnosis is a very important feature, and one must differentiate from tuberculous ankle, severe sprain of long standing with periarticular adhesions, and from malignant disease of the ankle.

The presence of extra heat about one or both of the malleoli, with bony enlargement, abduction of the foot, spasm on passive movements, and atrophy of the calf, will enable one to diagnosticate a tubercular ostitis of the ankle.

The history of a sprain, with the usual treatment that is customary in such cases, with position of the foot, will enable one to make out a chronic sprain.

Malignant disease of the ankle or foot of course is very difficult to recognize, and is fortunately so infrequent that a mere mention of this disease is sufficient in the way of discussion.

Treatment.—The treatment of the two kinds of flat foot is—first, mechanical; second, operative.

In mechanical may be included the building up of the soles of shoes on the inner side, so as to throw the foot into better position and bring the vertical bearing in a line with the tarsus. It may be in the shape of springs within the shank of shoes, inserted by the shoemaker. It may be a high Spanish last, on which the boot is constructed. It may be an apparatus that is attached to the shank of the shoe on the outer

side and extends in a bar to the upper third of the calf, where a band secures it to the calf, the depressed arch being supported by a leather pad passing from the inner side of the foot over the malleolus and fastened to this upright bar on the outer side. All of the devices just mentioned have their place in the management of the atonic forms of flat-foot, and even in some where there is a moderate degree of spasm.

In the severer forms, however, operative procedures are called for, and these include correction of the deformity under an anæsthetic, with an attempt to reduce the luxations or subluxations, the various operations of the bone, division of the tendo Achillis, etc. From my own observation and experience with a very large number of cases of flat-foot I am prepared to doubt very seriously the value of any bone-operations. Indeed, I do not know of any cures that may be regarded as permanent or that may be regarded as perfect from these procedures; while, on the other hand, I do know of a large number of cases successfully treated by manual replacement under an anæsthetic, supplemented by a flat-foot spring. The spring which has been most serviceable in my hands is that known as the Whitman spring. Indeed, I cannot do better than give an outline of Dr. Whitman's management of a case:

If the deformity can be over-corrected without an anæsthetic, then, under manual force, this is done. If this is impossible, under an anæsthetic the foot is converted from a valgus into a varus. The tendo Achillis is stretched, so that all the elements which go to make up a case of flat-foot are done away with. It is specially important to over-correct and to break up the adhesions that may exist. The foot is immediately placed in plaster of Paris in this over-corrected position, and at the end of a fortnight the plaster is removed, the sprain found pretty well under control, and a cast of the foot taken in the best position possible for walking. From this cast is made an iron cast on which a spring can be hammered out so as to fit the shank of the foot. This spring, when completed, has three points of bearing—the outer side, the posterior and anterior portions. The inner side is well raised, is deeper than the outer side, and furnishes an excellent support for the foot. The steel, after it has been properly shaped, is tempered, polished, nickel-plated, and finally shellacked. It can be made suitable for any shoe and furnishes an adequate means of support. Before this is completed the treatment for the foot consists of daily manipulations with hot-water douche or hot baths, with an effort on the part of the patient to toe in as he walks. Indeed, Dr. Whitman prefers a Waukenfast shoe. As supplemental, exercises may be employed. Massage is useful. The aim really is to restore the muscles to their proper tone, to make them, by being replaced in normal position, useful in supporting the arch, and eventually the spring may be discontinued.

Rhachitic Deformities.

Under this heading may be included pigeon-breast, bird's-nest deformity of the thorax, rhachitic kyphosis, knock-knee, bow-legs, antero-posterior curvature of the long bones, and weak ankles.

Pigeon-breast.

Pigeon-breast, known as pectus carinatum, is a deformity that is of no very great significance, and is hardly worthy of a place in a text-book of surgery. It should be mentioned, however, if for nothing more than to impress upon the reader the difficulty of effecting a cure. The various devices for correcting a deformity of this kind are usually discarded after a little use of the same. The parents, somehow, seem to prefer the deformity to the remedy. A truss-spring similar in shape to an ordinary truss, with pad in front and over the back, is the most common device employed, and in a few instances I have seen the deformity undergo a moderate recession. Ordinarily, the mother's hand is about the best treatment, and to employ this agent satisfactorily the mother should be taught to make firm pressure against the protruding chest-walls while the child takes free inspirations. This procedure, employed for fifteen or twenty minutes a day, extending over a period of two or three months, really alters the shape of the thoracic walls a good deal, yet on account of its simplicity it is very difficult to carry out any systematic treatment of this kind.

Bird's-nest Deformity.

The bird's-nest deformity is a marked depression at the lower end of the sternum, resembling a bird's nest, is of very infrequent occurrence, and no satisfactory means have been devised for its correction. Indeed, it is of very little significance one way or the other, does not interfere with a child's health, and is simply objectionable from a cosmetic point of view.

Rhachitic Kyphosis.

A general antero-posterior curvature of the spinal column is the characteristic feature of rhachitic kyphosis. In the foregoing nothing has been said concerning the etiology or pathology of rickets, for the reason that a full discussion of the subject is better adapted to a work on pædiatrics.

The age at which these changes occur is between the first and third year of life. The spinal deformity, however, occurs prior to the first year, as a rule. The causes which produce rickets are present at this period of life, and the position in which the child is held contributes largely to the mechanical production of the deformity. It persists even beyond the third year, and is easily recognized by its relationship to other rhachitic changes in the body; for instance, the beading of the ribs, the sternal deformities, the epiphyseal enlargements, the abdominal appearances, the deformities of the lower extremities. While cases of rickets differ according to the severity of the lesion, a reasonably careful examination will enable one to differentiate the curvature of this disease from that of tuberculous disease of the bodies of the vertebræ. A very easy method of making a differential diagnosis is this: Place the child in the prone position either across the mother's lap or on a table. Grasp the feet and legs with one hand, and with

the other hand over the back as a fulcrum attempt extension of the spine. If it be rhachitic, the deformity will disappear, or at least so nearly disappear that the flexibility of the column can be easily established. If it be the kyphosis of Pott's disease, the deformity will not disappear and the spinal column will appear rigid. Again, the kyphosis of Pott's disease is, as a rule, sharply angular, while that of rickets is more in the nature of a curve, and, indeed, one can speak of a posterior curvature of rickets, while the term is not appropriate for the kyphosis of Pott's disease. After all, the diagnosis is the chief point of interest in rhachitic kyphosis.

The **treatment** is mostly constitutional and positional. It is very seldom that apparatus is called for in the correction of this deformity. The flexibility of the column itself is sufficient guide in the way of treatment, for one can readily see that the upright posture contributes to the increase of the deformity, and naturally the recumbent, whether prone or supine, will afford relief. The nurse or mother can easily be instructed as to the best position in which to place the child throughout the day as well as by night. There is nothing better than one's hand or arm on which the child can rest, the trunk acting somewhat as a see-saw. It is of course not meant that the hand or arm should be continuously employed in this way, but a number of times a day for short periods. The prone posture, the supine as well, with a pillow on which the back can rest, should be maintained at night.

In cases of congenital rhachitic kyphosis an apparatus of some kind is nearly always required—a simple antero-posterior spinal assistant, such as the Taylor brace for Pott's disease or the Knight spinal brace. Plaster of Paris cannot be made available, because of the peculiar shape of the body. The congenital deformities from rickets are so rarely met with that detailed accounts of appliances must necessarily prove of little avail in discussing mechanical treatment.

Any system of feeding which is accompanied by signs of rickets should, of course, be abandoned, and another system substituted. So little attention is given to infant feeding by the family practitioner that a child may suffer from rickets for months, and even develop deformity, before medical or surgical advice is sought. Pædiatric literature is cultivated to such an extent that it is fair to presume that there will be a more general knowledge of the care of infants diffused into the professional mind, and that greater attention will be given to the early stages of rickets.

The More Common Rhachitic Deformities, such as Knock-knee, Bow-legs, and Anterior Tibial Curves.

Knock-knee.

The term knock-knee has for synonyms Genu valgum, In-knee, Genu introrsum. The Germans employ the term Knickbein, X-bein, etc. etc. The names are sufficiently explanatory of the appearance of the deformity.

Knock-knee appears about the time that the child begins to walk. It is occasionally seen before this period. In adolescence it sometimes

presents, but is not so often of rhachitic origin at this period. There are a number of factors which contribute to the production of knock-knee, such as bony changes at the articular surfaces, lengthening of ligaments, and general lack of muscular tone due to the disease itself. There are three bony deformities found in knock-knee, any one of which is sufficient to produce the deformity: the condyles of the femur differ in size; the articular facets of the tibia are unequal; the shafts of the bones may curve. It is easy to recognize the changes in the condyles by flexing the knee sharply and noting the difference in length. An antero-lateral curvature of the femora is often associated with the difference in length between the condyles, and, indeed, one might depend upon the other. There are various grades of this deformity, and one finds the text-books fully illustrated. It is sometimes unilateral, or you may have knock-knee on one side, bow-leg on the other. For instance, in Fig. 316 we find a very good illustration of the two deformities in one subject.

Fig. 316.

Knock-knee and bow-leg in same subject.

It is safe to assert that any case of knock-knee can be cured; it is also safe to assert that many cases undergo a spontaneous cure. It is exceedingly difficult to obtain statistics bearing upon the spontaneous cure of knock-knees, for the reason that the minor grades of the deformity seldom come under observation at the clinic, and the general practitioner attaches so little importance to the subject that he is unwilling to devote any time to a collection of observations.

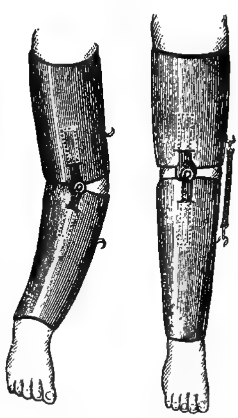
Following Bradford and Lovett, the treatment may be divided into three divisions: first, expectant; second, mechanical; third, operative.

The expectant treatment is sufficiently safe for the milder cases, for the term "expectant" itself presupposes frequent observations, with

attention to the dietetic details and to hygienic regulations. For instance: If a given case come under observation for the first time, one naturally looks into the question of diet, into the question of hygiene, and into the general condition of the muscles, bones, and ligaments. Tracing may be taken or not of the deformity. If it is very slight, of course this is not done, but where it is of moderate grade, then it is certainly wise to take a tracing of the limbs as they lie naturally on the table or in the best position into which they can be forced. Such a record may easily be kept for comparison later on, and after a few months of waiting—expectant treatment, as we call it—the physician can easily determine whether to resort to mechanical or operative procedures. Children who live in the country, and those who have even good hygienic surroundings in cities, are subjected to the expectant treatment with gratifying results. The main difficulty is to overcome the mother's objections to the deformity from a cosmetic standpoint.

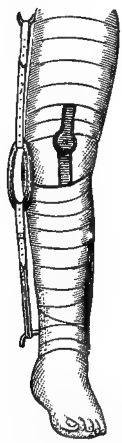
The mechanical treatment is called for in cases that fail under the expectant plan and in cases where the deformity is very pronounced—a deformity which is easily recognized as depending upon bony changes. The age for the most efficient mechanical treatment is between the second and the fifth years of life. Beyond the fifth, in my experience, mechanical treatment accomplishes very little. The bones have become so hard that it is difficult to make any impression upon the elongated internal condyle, and if enough force is employed the patient complains so much that the parents become very lax in attendance. My own plan is to advise against mechanical treatment, as a rule. Devices such as building up the shoe on the inner side, so as to throw the weight toward the outer border of the foot, sleeping at night with pads between the knees, feet

Fig. 317.



Mikulicz's plaster bandage (Schreiber).

Fig. 318.



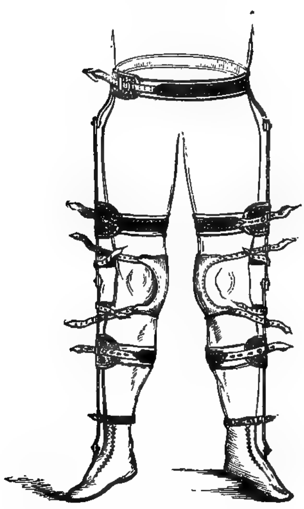
Vogt's plaster bandage with elastic traction (Schreiber).

bound together, keeping the child off the feet as much as possible, serve me a very good purpose.

If one decides to employ apparatus and can overcome the objections on the part of the parents to confinement to bed or a wheeled chair,

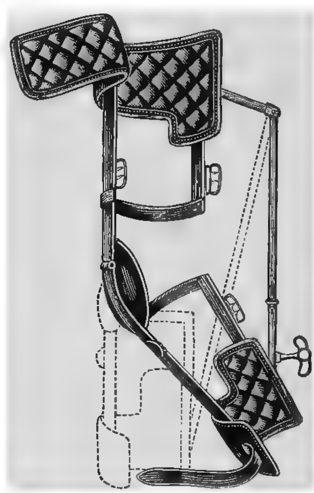
almost any form of apparatus will be serviceable, provided sufficient care is given to the application of the same. Any appliance which allows motion at the knee is not so efficient as that which is employed without motion. The child can very easily walk with the knees held immobile, and will soon acquire proficiency in walking. Plaster of Paris may, therefore, be employed. The limb can be forced into a very good position without an anæsthetic, plaster can be applied, and within a fortnight the procedure can be repeated. The plaster dressing employed by Mikulicz is very efficient. This is shown in Fig. 317. The elastic traction may also be employed in conjunction with plaster, after the method of Vogt, as in Fig. 318. The most common form of apparatus furnished by the shops is that shown in Fig. 319. In ordering apparatus of any kind it is well that the surgeon should take his own tracing of the limbs—mark on the tracing where he desires the pads, the thigh- and calf-bands, and especially the joints. The Shaffer knock-knee splint is worthy of commendation, inasmuch as it can be worn while the patient is going about, but on account of its expense and the difficulty of adjusting it properly it is not generally employed. This is shown in Fig. 320.

Fig. 319.



Apparatus for knock-knee (Erichsen).

Fig. 320.

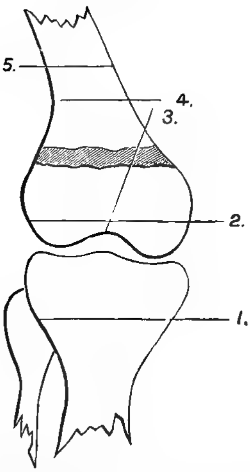


After the expectant treatment fails, and after a sufficient trial has been given to mechanical appliances, it is not difficult to get consent for an operation. In dispensary or hospital practice, however, operations are more frequently resorted to, because of the difficulty of getting apparatus in the first place, and any hearty co-operation after the apparatus has been obtained. For this reason operations are performed much earlier among the poorer classes. The indications for operation, then, may be summed up as follows: the age of the child, between six and ten years; the high degree of deformity; the extensive osseous changes which have produced the deformity; the failure of apparatus to afford

any relief. The operations themselves are, in the order of simplicity, manual correction under an anæsthetic—most extensively used by Delore, the French surgeon—the subcutaneous division of ligaments and tendons, osteotomy.

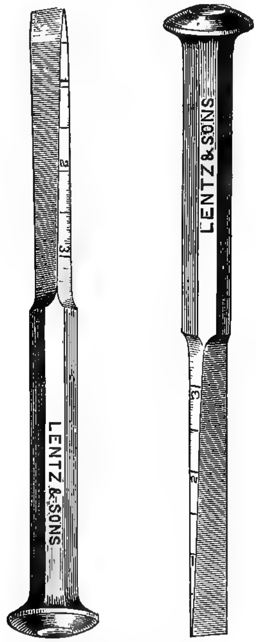
The manual correction is applicable to a very large number of cases, especially in children under six years of age. Beyond this age, however, it is difficult to accomplish much by any amount of manual force employed. The osteoclast may be employed, and parts may be sufficiently stretched with the instrument. A fracture produced by the osteoclast is about as easily healed as a severe sprain of the joint, and for this reason the instrument is rarely employed unless an osteotomy is desired. After correction a strong splint may be employed, or, better still, plaster of Paris. At the end of two weeks the plaster should be removed, still further correction made, if necessary, without an anæsthetic, and the

Fig. 321.



Lines of osteotomy: 1, Mayer, Billroth, Schede; 2, Annandale; 3, Ogston, Reeves, Chiene; 4, Macewen; 5, Taylor.

Fig. 322.



Macewen's osteotomes.

plaster reapplied. It is necessary to employ some mechanical support, after plaster has been discarded, for two or three months.

If recourse is had to the knife—and the knife is frequently employed even in efforts at manual correction—it is necessary only to define the tendons or ligaments which are placed on stretch, and this can be easily done by the index finger; then thrust the tenotome directly upon the tense structures, nick back and forth, and increase the manual force. The open section of tendons or ligaments about the knee-joint is not advocated, even by the bolder surgeons.

Osteotomy is the operation *par excellence* for the older cases, and, without entering into details of the various osteotomies which have been advocated and from time to time abandoned, the operation of Macewen is the one that is most generally employed at the present day. A very good illustration of the lines of osteotomy is shown in Fig. 321. Macewen's osteotomes are shown in Fig. 322. Several years ago I abandoned the open method for Macewen's osteotomy, and have resorted to subcutaneous osteotomy by means of the Vance osteotome, which is similar to Macewen's, except that it is not so thick, has a sharp cutting edge, and is rounded off at the corners very slightly. With this instrument I am enabled to reach the bone without the employment of a scalpel, and can easily make section of the bone within a few minutes. The line of osteotomy is well known to be about a half inch above the condyle. The operation is done, of course, with antiseptic precautions. Care is taken to divide the bone at least through two-thirds of its thickness, after which the solution of continuity can be completed by manual force. The instrument is withdrawn before the effort at correction is attempted, a compress placed over the small wound, and healing of the superficial parts promptly takes place. In place of inserting the instrument on the inner side of the femur, as does Macewen, I resort to McCormick's modification, which is to insert on the outer side. This gives the advantage of making a kind of hinge of the inner structures of the bone and effecting complete solution of continuity. It is well to over-correct and put the limb up in plaster from the free ribs down to the ball of the foot. In order to make the plaster lighter and ensure better fixation, I shape one or two bars of steel to the corrected position of the limb, and incorporate this steel within the folds of the plaster. Union takes place, as a rule, within four weeks, at the end of which time the plaster can be changed. At this period, too, a little better correction can be made if it is found desirable. Three or four weeks' longer use of plaster is sufficient to complete the cure. The convalescing treatment may be a light spring attached to the heel of the shoe and extending up to a pad on the outer side of the thigh. Indeed, the knock-knee spring of Hugh Owen Thomas is a very convenient convalescing brace. This consists of a stem of iron or steel which extends along the outer side of the limb, from a crucial-shaped pad at the upper third of the thigh, down to the front of the heel, where it is curved into the shape of a small rod, which passes through a hole in the heel extending to the inner side. A posterior bar from the popliteal space to the lower portion of the calf is joined to the side-bar by means of cross-bands at either end. This posterior portion is merely to keep the appliance in place. A roller bandage to hold the limb over to the outer bar completes the dressing.

The knock-knee of adolescence is usually of rhachitic origin. Baker's knock-knee is not rhachitic, but depends upon the peculiar position in which the patient is obliged to stand a certain number of hours a day. The treatment is confinement to bed with side splints, and subsequently a walking apparatus. By some the treatment is regarded as exceedingly unsatisfactory, but, as far as my own observation goes, a few weeks in bed with rest to the parts accomplishes a great deal in the way of relief and makes the convalescing treatment very simple.

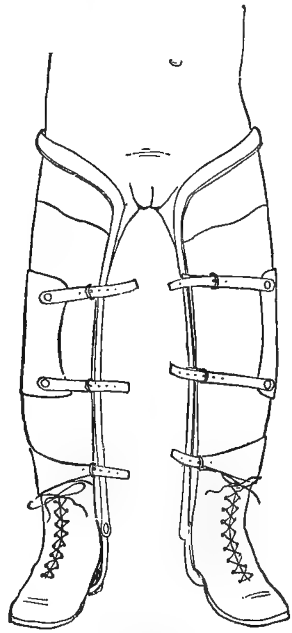
Bow-legs and Anterior Tibial Curves.

The etiology and pathology of bow-legs are practically the same as those of knock-knee. I shall proceed, therefore, to the treatment, which is governed by the same general principles as that of knock-knee. First, we have the expectant, which is sufficient for a large number of cases; the mechanical; and the operative.

Fig. 323.

Knight bow-leg springs.

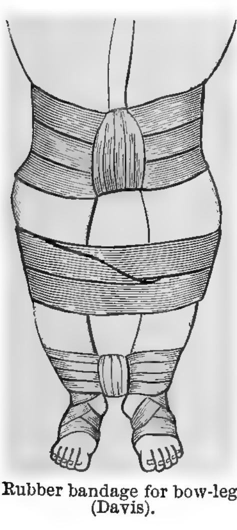
Fig. 324.



Apparatus for bow-legs (Bradford and Lovatt).

There are mild cases which require practically no treatment and which correct themselves. One hardly expects a case to correct itself, for the

Fig. 325.



Rubber bandage for bow-legs (Davis).

Fig. 326.

Grattan's osteoclast.

reason that the curve is rather low in the tibia and requires an osteotomy for its correction. A reference to the remarks on the expectant treatment of knock-knee will enable one to judge equally well about the indications in bow-legs.

A very fair illustration of a pair of bow-leg springs is shown in Fig. 323. The apparatus here presented is known as the Knight bow-leg spring, and differs in some unessential details from the ordinary springs of the shops. All are intended to make pressure against the convex side of the limb from a bar passing up the inner side. In Fig. 323 there is a heel-cup and foot-plate, and a free joint at the ankle. The inner bar extends from the joint on the inner side to a pad just over the condyle. The outer bar extends from the ankle-joint to a calf-band. This outer bar is scarcely necessary, but is used in the Knight spring to assist in keeping the apparatus in place. Where the curve is general and extends through the entire length of the limb there is usually little need to have any apparatus; yet where the deformity is evidently increasing an appliance such as is shown in Fig. 324 will answer the purpose. Young has presented a very ingenious mode of employing the rubber bandage, which for patients in the recumbent posture might prove of great service. This is shown in Fig. 325.

The operative treatment is manual force, which may produce a green-stick fracture of the limb or even a fracture of the bone. The osteoclast is employed by a certain number of orthopædic surgeons, yet the general surgeon prefers a simple osteotome. A

FIG. 327.

Case of bow-legs.

FIG. 328.

Bow-leg from loss of tibia.

fair sample of the osteoclast is shown in Fig. 326, and is known as the Grattan osteoclast. I must confess that I have never been enamored of the osteoclast, as I have always been able to effect a fracture by manual force or a correction of the deformity by a subcutaneous osteotomy.

Not wishing to present cases, as most of the works are replete with illustrations of cures by osteotomy, I will omit illustrations showing the deformity as well as the result. Fig. 327 presents a most extraordinary case of bow-legs, due to faulty articulations at the knee. The child presented congenital absence of the radius on both sides. In this instance I did a cuneiform osteotomy below the epiphyseal line, not making a complete solution of continuity of the bone. The result was about perfect.

In Fig. 328 we have a case of bow-leg due to destruction of the tibia. This child suffered in early life from necrosis of the tibia. In the efforts at removing the sequestrum the lower portion of the bone was destroyed, and, as she began walking, there resulted, naturally, a most extraordinary degree of bow-leg. Dr. William T. Bull did a very satisfactory operation by uniting the fibula with the upper end of the tibia. The result is shown in Fig. 329.

The concluding remarks on bow-legs may be summed up as follows: Milder cases require neither mechanical nor operative treatment. Even

Fig. 329.

Result in Fig. 328.

exaggerated cases, where the curve involves the whole length of the limb and where there is spraddling, so to speak, do not require treatment. Children under four years of age presenting even a marked degree of bow-legs may be completely relieved by the use of apparatus. Repeated

attempts at correction with manual force, supplemented with plaster of Paris, are sufficient to cure a large number of cases. Osteotomy is preferable to osteoclasis if the osteotomy be subcutaneous. Cases where there is an anterior curve of the tibia require, in rare instances, a cuneiform osteotomy. Cuneiform osteotomy should be reserved for a high degree of anterior curvature of the tibia, but never used for bow-legs. An exception may be made to this rule where the articular surfaces of the joint are defective, and then one must depend upon his individual surgical judgment.

Paralytic Deformities.

Under this heading may be included many forms of club-foot depending upon cerebral or spinal paralysis, deformities at the various joints depending upon muscular shortening or muscular spasm, and subluxations and luxations of the joints.

The most common form of paralysis from which deformities result is that due to poliomyelitis of infancy. Cerebral paralysis produces usually one deformity of the foot—namely, an equinus; and one of the hand—a contraction of the fingers. Peripheral paralysis is seldom followed by any extensive deformity, and will be considered in this connection only as one of the causes of a deformity for which poliomyelitis is most frequently responsible.

The general practitioner and the neurologist have come to the conclusion that little in the way of restoration of a muscle palsied from poliomyelitis after a certain period, say one year, can be accomplished by electricity or massage, or both. Attention is given much more generally now to the deformities which result. It is the province of the orthopædic surgeon to prevent these deformities, and certainly his opportunity is better now than it was in former years. It is not intended to discriminate against electrical treatment, but it is a fact that electrical treatment can be carried on to much better advantage where joint-strain is prevented by mechanical means.

There is really nothing complicated about the mechanical support for these paralytic limbs. If we have a drop-foot to deal with, an apparatus which will hold the foot at a right angle with the leg will rest the anterior tibial group. If both anterior and posterior tibial groups are palsied, then there needs to be a limited joint—that is, a foot-plate set at a right angle with the upright and arranged so that a very small arc of motion will be permitted. This appliance, for the poor, ought to be inside of the shoe. For the better class of patients it can be attached to the shank of the shoe and an extra steel spring carried throughout the sole. If the quadriceps femoris be paralyzed, then the appliance should extend above the knee—say, to the upper third of the thigh. A spring joint can be applied at the knee, so that when the patient assumes the upright position the flexed leg will extend and by its own weight lock the joint at the knee. If the patient wishes to sit down, he can touch a spring or slip up a peg of some kind, which will liberate the lock-joint and flexion can occur. These appliances are so very common that it is hardly worth while to illustrate. The cheaper forms of apparatus are those which do not permit of any motion at the knee. The limb is simply bound to the uprights and a peg-leg is made of the limb. For

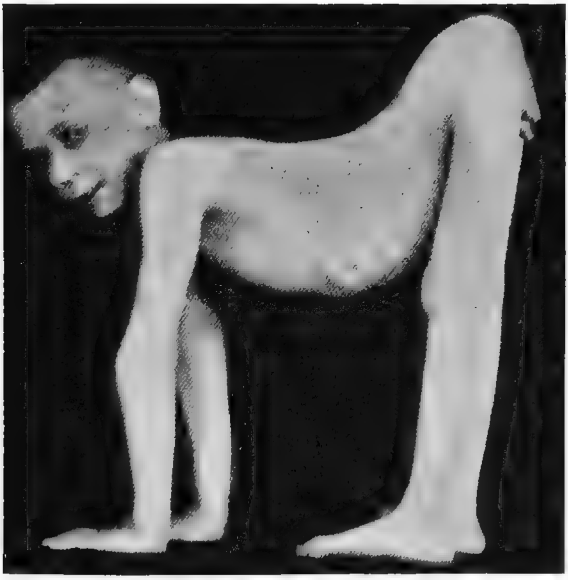
young children a joint is entirely unnecessary, and, indeed, is rather a disadvantage, for the joint-ligaments are strained a good deal by the movement and the muscles which need protection are not so well pro-

FIG. 330.

Paralysis from poliomyelitis.

tected. There need be no fear of ankylosis or stiffness of the limb from prolonged immobility. The joint can be moved a little night and

FIG. 331.



Extreme deformity in paralysis.

morning, and all dread or fear of ankylosis can be thus dispelled. For charity cases a joint is not employed under ten years of age. Where

the thigh flexors are involved or where the gluteal group of muscles are palsied, so that the head of the bone is not held securely in the acetabulum, a pelvic band is attached to the upright support, and with such an apparatus the patient is able to get about with a fair degree of facility. It is employed extensively at the Hospital for the Ruptured and Crippled. It is, of course, applied after all deformity is corrected. The case is usually one of dangle-leg, and with the appliance the patient can get about very often without the aid of a crutch. As the patient grows older it becomes a very serious question whether the apparatus should not give way to an excision of the joints for the purpose of producing synostosis. It is astonishing how lax the joints may become after a poliomyelitis, and a very good illustration is shown in Fig. 330. A case like this requires apparatus on both sides, with pelvic band. Crutches are needed as well.

FIG. 332.

After section of muscles.

The operative treatment consists of subcutaneous division of tendons and muscles, division of the same by open section, manual force under ether, with the immediate application of plaster of Paris to maintain the good position. The plaster gives way after a few weeks to some form of support. It is possible to divide the tendons about the foot, the hamstring tendons, the tensor vaginæ femoris, the adductors of the thigh, and even the fascia lata—all subcutaneously. Where these simple procedures fail, it is very easy then to make open section and divide muscles, tendons, and fascia as they present under the finger. A very interesting case of deformity is shown in Fig. 331. This boy was known in the hospital as the "Kangaroo Case." The figure shows his mode of locomotion. It was simply impossible for him to extend his thighs, the flexors at the hip were so very short. Under ether an open incision was made and all the muscles down to the capsular ligament were divided; that is, all muscles which presented any resistance to extension. Within a few weeks he was walking on crutches and apparatus, no longer quadripedial. He has attended school for the past three or four years. I have recently had him photographed, and the result is shown in Fig. 332. He still presents a little deformity at the hips, but is able to stand with very little assistance, without apparatus of any kind, but with the apparatus he goes about and attends as an out-patient.

The operation of arthrodesis, which is an effort to secure ankylosis at a joint, is often indicated, especially where it is difficult to keep apparatus in repair and where the patient is unable to bear the expense

At the ankle-joint the articular surfaces can be easily reached and pared off, and union should take place without any suppuration. The same is true of the knee-joint. The operation is seldom called for at the hip. Where this seems a necessity it would be better to amputate.

Diseases of the Joints.

General Considerations.

It is generally conceded that American surgeons have made the greatest advance in the treatment of not only the diseases which implicate the joints, but of the deformities which result from these diseases. It is therefore fitting that a treatise on orthopædic surgery should include both acute and chronic diseases of the major, as well as the minor, articulations. As already outlined in the earlier part of this dissertation on orthopædic surgery, the prevention as well as the correction of deformity demands most careful consideration. In discussing the joints it is unnecessary to divide the subject into different parts corresponding to the joints involved, except in so far as treatment is concerned. In a general way we can treat of the etiology and the pathology.

Nomenclature.—The rôle which tuberculosis plays in the etiology and pathology of the diseases now under discussion enables us to name two general divisions—tubercular and non-tubercular. Then, again, we have acute and chronic—the acute rarely tubercular, the chronic, as a rule, tubercular. The above statement must be taken in the light of a marked difference between the chronic joint disease of children and of adults. For instance: the majority of cases of such disease in children are tubercular, while in adults the non-tubercular diseases predominate. The division, anatomically speaking, is the following: Periarthritis, arthritis, synovitis, articular ostitis, osteo-arthritis. It is admissible to name a disease after the joint involved—for instance, shoulder disease, hip disease, knee-joint disease, etc.—yet a nomenclature of this kind is misleading. It is not sufficiently scientific, for the reason that accurate diagnoses are seldom required and the therapeutics must, of necessity, be unsatisfactory. The term "traumatic" as applied to joint diseases is not so generally employed as it was one or two decades ago.

Taking up the different joints, we have in common use the following nomenclature:

For the joints of the upper extremity:

Periarthritis, arthritis, tubercular ostitis.

In the lower extremity:

For the hip: Hip disease—a very common term—hip-joint disease, morbus coxarius, coxitis, tuberculosis of the hip, articular ostitis of the hip, periarthritis, rarely synovitis, bursitis, neurosis.

For the knee: Periarthritis, acute synovitis, chronic synovitis, hydrops articuli, hydrarthrosis, tumor albus (white swelling), arthritis, osteo-arthritis, internal derangement of, bursitis of the knee, neurosis, Charcot's knee.

For the ankle: Periarthritis, arthritis, tubercular ostitis, white swelling of, caries of, neurosis of.

Etiology.—Acute joint diseases are, as a rule, traumatic. Exceptionally, we have the idiopathic disease depending on a germ of some kind. The chronic affections of the joint depend, in children, primarily upon the bacillus of tuberculosis. In adults they result from a sprain of some kind; that is, trauma, from rheumatism or gout, and from certain lesions of the nervous system. It is unnecessary to dwell in detail upon the mode of invasion of the bacillus of tuberculosis. It is simply enough to say that the germ is introduced into the system, that it finds its way to the bone-ends, and there develops an ostitis from which an arthritis may result. It is conceded that in a number of chronic joint diseases in children, tubercular in nature, a slight trauma of some kind has served to make active the tubercular focus, and in this way contribute to the development of a typical tubercular ostitis of the joint.

Pathology.—A joint that is primarily involved in disease shows changes in the articular cartilages, and about the same time in the synovial membrane. When trauma is the cause the changes may be at first quite well marked or scarcely significant, yet the use of the joint before Nature has had an opportunity of repairing the mischief done tends to an increase of the hyperæmia and the destructive changes which follow an inflammatory process. The deeper structures are involved secondarily in such cases, while a very marked lesion may be in progress within the joint itself. For instance: one may have a gelatinous condition of the synovial membrane of the knee, distinctively tubercular, while the deeper layers of the cartilage may be scarcely involved at all. Where the disease is primarily ostitic the joint-changes are then secondary, and extensive lesions may exist in the bone-ends, while very slight inflammatory changes may exist in the joint itself. Indeed, joint-changes may undergo complete resolution, and a focus of disease in the bone—a cavity, for instance—may exist for many years. Bone tuberculosis is so intimately associated with the chronic joint diseases of children that we can seldom disassociate the two. In adults other changes, such as a fibrillation of the synovial fluid, are characteristic of rheumatic affections. The most important changes that take place, and changes which call for the services of the surgeon most frequently, are subluxations, luxations, and the usual adhesions which belong to ankylosis.

Treatment.—This can be discussed only in a general way. The principles which underlie the management of diseases of the joints are rest and protection. As supplementary—and, indeed, one might say complementary—to those two principles we have diet, hygiene, and everything which tends to build up and restore the general health. Details as to how rest and protection shall be secured, the time when these principles shall be discarded, the necessity for motion, for instance, and use, more properly belong to the individual joints now to be considered.

Ostitis of the Hip.

Clinical History.—The disease first makes its appearance in the shape of slight stiffness at the hip, with a little lameness, scarcely appreciable. The pain is usually an early symptom, and this is referred to the knee as well as to the hip. Indeed, the pain in the knee so often precedes the pain in the hip that one is deceived, and very often mistakes the knee-

pain for disease at this articulation. The story which parents bring is about as follows: The child had a fall, usually a very insignificant fall, and afterward began to show a little lameness, stiffness about the hip, would fall easily, cry if handled at all roughly, etc. etc. A little cross-examination brings out a long interval usually between the fall and the first symptoms which the mother can recall. By "long" is meant from one to six or twelve months. Indeed, it is learned that the fall is an after-thought, and that it requires some little investigation on the part of the family to learn about the fall. The symptoms are so very slight at first that it is not thought necessary to call for any medical advice, and within a few days or a week the little patient is much better. Indeed, the parents believe that there is no limp whatever. The rule, however, is a limp always, and there are very few cases on record where there has been any positive evidence as to the complete disappearance of the limp. After the subsidence, more or less complete, of this group of symptoms, which we are in the habit of terming an exacerbation, there comes a remission, which extends over a variable period—from one or two weeks to two or three months. The second exacerbation depends usually upon some slight trauma. The child, by reason of its awkwardness and the care necessary to avoid any distress, gets a fall or a bruise of some kind, and there is a repetition of the first train of symptoms. Usually these are a little more exaggerated. The lameness is more pronounced. At the first attack there may not have been any night-cries. During the second one night-cries come on, as a rule, and are very characteristic. They are not continuous through the night, but the mother hears a shriek or a scream, goes to the little fellow's bed and finds him sound asleep, or sometimes finds him with the thigh flexed on the abdomen and holding the knee with his hands, still dozing off to sleep. If she watches a while by the bed, she observes some spasm of the limb, some grimaces of the face, a scream in the sleep. When the muscular spasms become severe, the child awakes and will cry for a little while. Intelligent mothers sometimes make this observation—that if the limb be held and slight traction made the child will go off to sleep, and sleep well as long as the traction is continued. After one or two weeks, or a little longer perhaps, the symptoms just described subside in a measure, and there are less pain and less discomfort, but the lameness then seems to be permanent. Every one is convinced that the child is actually lame. The family physician is usually consulted about this time, and if he be a careful man and has acquired the habit of going over his cases with the thoroughness that is requisite, he finds considerable impairment of motion—tenderness in making these movements. There are no swelling and no deformity. The family history is usually obtained. The child is generally quite robust-looking, and the customary opinion given is that it would be well to await further developments—that it is difficult to determine the nature of the trouble. The second remission is followed by another exacerbation, and the examination made usually results in a diagnosis.

While the above is representative of a typical case, there are many atypical instances of hip disease. For instance: The first group of symptoms may be very slight, very insignificant, and the first remission may last from six months to a year, with scarcely any changes during the

remission. Whatever symptoms develop can scarcely be dignified with the name of an exacerbation. Again, the invasion may be very sudden, very acute, and deformity may result within a few days—a deformity which is characteristic of the advanced stage. This exacerbation may last for many weeks, or months even, during which time the child is confined to bed or hobbles about on a crutch, or, if he walks at all, walks with great lameness. The subsequent exacerbations are usually not so acute.

The disease, it must be noted, is characterized by exacerbations with remissions, and by certain stages which have long been recognized and are named first, second, and third.

The first stage corresponds to the early invasion, and is marked by the symptoms which have been described in the early part of this section, marked by the absence of deformity and with a very slight limp.

The second stage begins with the occurrence of deformity, and is marked pathologically by certain changes in the bone-substance itself. The structures about the hip have become shortened a little, so that it is difficult to correct the deformity even by manual force. During this stage abscess appears, and the pressure of the sac upon the soft tissues contributes a good deal to the deformity and causes pain of a different character from that in the early stage. The limb is much more sensitive. The deformity is usually an expression of the severity of the case.

The third stage is marked by the beginning of shortening of the limb. Changes now take place in the relationship which the neck sustains to the shaft. In place of the normal obtuse angle the angle becomes very nearly a right angle. This is thought to be due to muscular spasm, on the one hand, and walking on the limb, whereby the weight is thrown against the impaired head and neck, thus giving prominence to the trochanter major. We have then a deformity at the hip which is sometimes regarded as a dislocation, because the trochanter is so prominent and because it comes above Nélaton's line. Nélaton's line, it must be understood, is a line drawn from the tip of the anterior superior spinous processes to the tuber ischii.

The third stage, then, is the stage of shortening; the second, of slight deformity; the first, of no deformity. The clinical history of the second stage is that of very sharp exacerbations, long continued, attended with abscess, which occasionally disappears—usually goes on to open spontaneously. When the abscess does open, the hectic fever ensues, the general nutrition is much impaired, the child suffers from loss of sleep, and the case may be severe or mild in proportion to the extent of the original lesion. This is the stage of crutches, of wheeled chairs, of confinement to bed. The third stage is very similar to the second in its history, but may include reparative process as well as destructive. If the former, the child gets about without crutches or support of any kind, but still has a very pronounced limp and the shortening is very marked. If the latter, there is a long period of confinement to bed, progressive emaciation, development of amyloid changes in the liver and kidney, attended with albuminuria, urine with low specific gravity, œdema, anasarca, and death. A fatal issue may ensue without involvement of the liver and kidneys, and the child may simply waste away and die of exhaustion.

It should also be noted that the second and third stages are not

always of the typical form, and are not as above described. Indeed, the second stage may present a very slight amount of deformity, and may not present any abscess whatever. The third stage may present the usual shortening which characterizes the stage, and yet no abscess be present. Roughly speaking, abscess appears only in about 50 per cent. of the cases, and if appropriate treatment be early employed 80 per cent. may escape abscess, The abscess itself usually results in a sinus, and the limb will be marked by sinuses, ultimately by cicatrices where a favorable issue takes place.

FIG. 333.

Position assumed in standing, with slight abduction of right leg (Bradford and Lovett).

It is difficult to illustrate by photographs the different positions which the hip assumes during the course of the disease. The changes in the first stage are usually about the nates, and it requires very close photography to bring out the slight variations from the normal. The second stage is very well illustrated in Fig. 333. The third stage is more easily illustrated. For instance, in Fig. 334 we have the third stage, which shows the deformity in flexion, and this flexion can be best made out by so placing the patient on a table that every one of the spinous processes will come in contact with said table. In Fig. 335 the same patient is standing, and shows the lordosis. Again in Fig. 336 we have the third stage well illustrated, and the cicatrices are shown as well. In addition to this, there is extreme equinus, which has resulted by reason of the patient's efforts to walk. A very good illustration of abscess is furnished in Fig. 337. This occupies a very

FIG. 334.

Deformity of third stage.

favorite site. Deep femoral abscess is, fortunately, uncommon, since it is exceedingly difficult to manage, for the reason that it encroaches upon

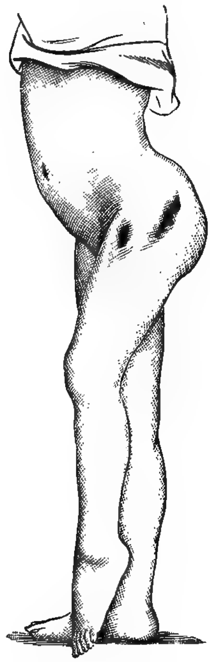
the femoral vessels and interferes with operative treatment as well as the expectant.

Diagnosis.—It is exceedingly important to recognize the deformity in its early stage. In order to do this a very intimate knowledge of the clinical history and nature of the disease is essential. While every one cannot possess the information by clinical experience, every one can acquire a routine habit of making his examinations, and can cultivate a power of observation which all medical colleges should teach.

Fig. 335.

Third stage.

Fig. 336.



Third stage after abscess.

There are certain signs which are regarded as pathognomonic, and these are few, while there are many other signs and symptoms which, taken collectively, go to make up a case, and a knowledge of which will enable one to make a diagnosis before any deformity arises. The pathognomonic signs are resistance to movement in all directions—this resistance accompanied with reflex spasm—and a characteristic limp. The ordinary symptoms are—changes in nates, flattening, for instance, of the same; loss or shortening of the ilio-femoral crease, atrophy of the limb, periarticular tenderness, night-cries, the typical scream, a history of an insidious invasion, and persistence in the limp.

To make a diagnosis, therefore, one should strip the patient, and while this is being done a history can be obtained. Then note the comparative measurements of the limb. Test the joint-functions, flexion and exten-

Fig. 337.

A hip-abscess (Lovett). (By permission of the Trustees of the Fiske Prize Fund.)

sion, abduction, adduction, rotation inward and outward. These tests should be made carefully and deliberately. The sound hip should be put through all the movements that we attempt on the affected side. The child's expression should be noted when the affected hip is examined. In this way one can best discover the reflex spasm which is almost pathognomonic. It is not enough to move the limb over a small arc, but complete flexion should be attempted, complete extension, and complete *ab*- and *ad*duction. It happens very often that the reflex spasm is not excited until the limits of these movements are reached. Joint-tenderness is seldom present in the early stage—indeed, it is the exception to find it present—and in testing for joint-tenderness one should not strike the knee or the foot with a blow, aiming thereby to drive the head of the bone into the acetabulum, because the child involuntarily resists, and, while one may get pain, it is the pain of movement and not of the direct blow. Atrophy is mentioned, because this is a very common sign in all the varieties and stages of hip disease. It is not dependent upon constriction of the limb, but upon the involvement of the nerves implicated in the disease itself. The nutrition suffers. It is difficult to learn anything by palpation, although it is necessary to employ this means of diagnosis in one's routine method.

In the more advanced stages, second and third, diagnosis is not so difficult, and we make our examinations usually to determine how much

disease exists, whether the bony changes are very pronounced or not, whether the acetabulum is involved, what complications may exist, etc. etc.; and in this connection it may be well to state that it is next to impossible, in my own experience, to differentiate between the femoral and acetabular form in the early stage. Indeed, it is difficult enough in the advanced stages. If an abscess appears above Poupart's ligament, the presumption is that the acetabulum has been perforated, and in this way the acetabular form can be recognized. But there are abscesses which begin at first below Poupart's ligament, and burrow up, to appear in a place which would indicate the existence of the perforation of the acetabulum. The ordinary gluteal abscess comes from the digital fossa, and appears first as a small round tumor just above the trochanter major. Indeed, this abscess is sometimes mistaken for the head of the femur, and diagnoses of dislocation are often made when this small abscess is present. Palpation in the examination of advanced cases is therefore of great service. In making a diagnosis of amyloid disease we should find a low specific gravity in the urinary examination, albumin, and casts. Amyloid changes may be predicted by a low specific gravity of urine without the presence of albumin. The presence of pain in the hepatic region has often been noted by myself in observing cases from time to time, and I have come to look upon this as an important sign in diagnosis.

In making a differential diagnosis in the first and second stages we have to consider synovitis of the hip, periarthritis, phlegmonous inflammations within the pelvis and in the ilio-costal space, Pott's disease of the spine, hysteria (neurosis of the hip), poliomyelitis, and malignant disease.

The typical primary synovitis of the hip is so exceedingly rare that one seldom encounters this condition from which to differentiate. Many years ago I published a few cases of synovitis, but for ten or fifteen years I have not observed a single instance. We have an acute invasion, dependent upon trauma or exposure to severe cold, early deformity, in the first few days pain only of moderate degree, and a distinct fulness, which can be recognized deep under the gluteal muscles.

Periarthritis in children is usually phlegmonous in type—is attended with induration, rise of temperature, early disability, absence of reflex spasm, and absence of atrophy. The process may be acute or subacute. It is rarely chronic. Within a few weeks an abscess may form, the constitutional symptoms will be very severe, and, when the pus is liberated either by nature or the knife, a prompt recovery follows. In the rheumatic form of periarthritis the type is usually chronic. There is very little infiltration; other joints are involved, especially the knees, rarely the hip alone; the patient is an adult; and the usual signs above described for true hip disease are wanting.

In inflammatory conditions within the pelvis, such as a perityphlitic abscess or a perinephritis, there is the usual sudden invasion, attended generally with a chill, constitutional disturbance sufficient to keep the patient in bed, deformity within a day or two, and increase of the deformity. Palpation will enable one to recognize a deep-seated fulness either in the iliac fossa or in the ilio-costal space. In testing the hip as to function, *ab*- and *ad*duction will be free, while extension will be resisted.

In Pott's disease of the spine the limp differs from that of hip disease. While the child may favor the limb a little, it is not the step of fear

which characterizes the limp of hip disease. All the movements are normal except extension, and in Pott's disease, where it involves the last dorsal and first or second lumbar, there is resistance to extension by reason of irritation of the psoas and iliacus muscles. The absence of many signs that belong to hip disease will prompt one to examine the spinal column, to test its functions, and at the same time to explore the iliac fossa with the fingers. By exploring the iliac fossa I mean digital palpation with the thighs flexed, so that one can discover, even through the abdominal walls, the presence or absence of infiltration in the sheath of the psoas. In the Pott's disease we are now considering psoas abscess is frequently present, and the digital examination will enable one to recognize even a small abscess.

Neuroses of the hip simulate frequently certain types of hip disease. In getting the history hysterical symptoms will certainly appear. There will be spinal tenderness, tenderness following the course of the anterior crural or the sciatic nerve, hyperæsthesia of the skin supplied by these nerves, and a deformity of the hip which varies in degree from day to day; that is, at times one will note scarcely any deformity, while perhaps the next day there will be marked flexion of the thigh. Another neurosis of the hip is that dependent upon irritability of the spinal nerves, brought about sometimes by exposure to cold. In my own experience boys from ten to twelve or fourteen have presented this form of neurosis more frequently, and the neurosis seems to follow exposure to cold; that is, I know of several instances where swimming early in the spring or late in the autumn has been followed by rather acute flexion of the hip, pain, lameness, and disability. In girls about the same age chorea sometimes accompanies the deformity and makes the diagnosis rather difficult, but, after all, a routine examination, as above suggested, will enable one to eliminate all of the diseases that have been mentioned in discussing differential diagnosis.

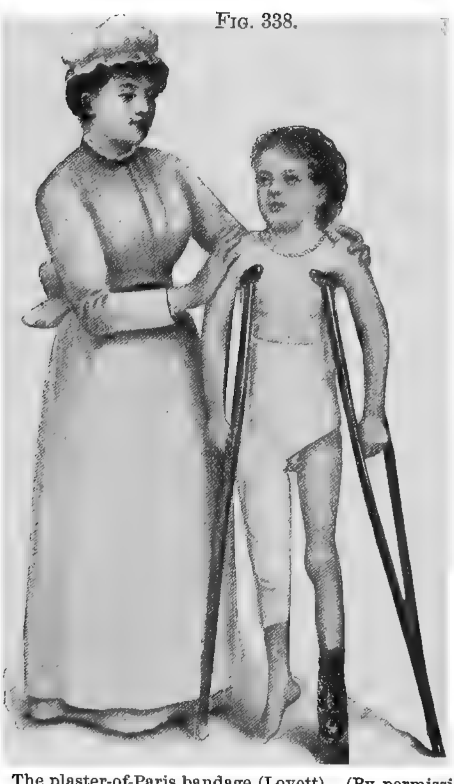
The two remaining ones, poliomyelitis and malignant disease, present greater obstacles, and yet a poliomyelitis has such a well-marked history of invasion that a test of the functions of the joint will enable one ordinarily to make a diagnosis. If the examination be made within a week or two from the invasion, there is so much hyperæsthesia about the limb and the joint itself that one must exercise great care in eliciting all the facts in connection with the case.

In malignant disease the shaft of the bone or the pelvis is involved, rarely the head and neck, so that we must depend upon not only careful physical examination, but the history; which history is replete with very sharp pain, burning in nature, which is not relieved by any methods of treatment. Fortunately, malignant disease rarely occurs in early childhood, so that the danger of an error in diagnosis is reduced to the minimum. In adult life we encounter malignant disease more frequently, and in adult life hip disease is the exception.

Treatment.—In discussing the pathology of joint disease reference was made to certain principles in treatment which were to be discussed more fully in treating of individual joints. In the early stage the joint should be put at rest. It is well, just as soon as the diagnosis is made, to put the patient to bed with weight and pulley, and employ enough weight to overcome the reflex spasm and maintain a good position.

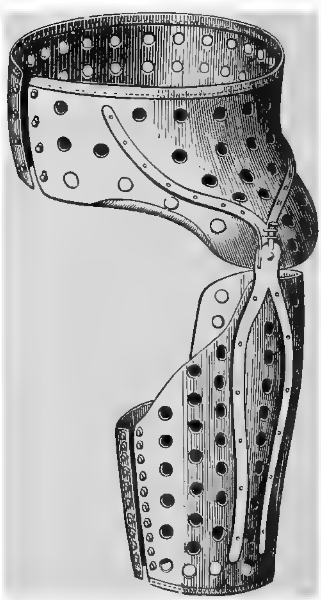
Relief will surely follow this method, but, as it is important to devise a form of treatment by which the patient can be up and out of doors, we fortunately have numerous appliances that can be adjusted and that can be easily obtained. If one is remote from a large city, it is well not to rely too implicitly on the various splints of the shops, but to employ some form of plastic dressing for the hip which can be supplemented by axillary crutches. What I mean is this: a neat-fitting and light plaster-of-Paris bandage can be applied from the free ribs down over the hip to the calf. In this way the points above and below the hip are immobilized as well. A high shoe on the foot of the sound limb, with a pair of axillary crutches long enough for this limb thus lengthened, will complete the outfit, and the patient can go about and get the benefit of hygiene and an out-of-door life. If one is specially skilled in the construction of leather appliances, a similar support can be made. It is necessary to bear in mind that the limb must be not only kept immobile, but the dressings must be so applied that the reflex spasm which occurs can do very little damage. The plaster or leather, for instance, which is employed should fit very snugly just above the condyles and about the pelvis. It should also extend well back of and over the trochanter major. I am convinced that a number of cases thus

FIG. 338.



The plaster-of-Paris bandage (Lovett). (By permission of the Trustees of the Fiske Prize Fund.)

FIG. 339.



Willard's hip-splint.

taken early by the family practitioner and treated as above described can be cured without shortening, without deformity, and with almost perfect

function. The employment of blisters and counter-irritants is of very little use, so far as my own experience goes. I am quite positive that counter-irritants in any form will do very little, if anything, toward arresting the disease, and I am sure that they will not prevent deformity.

Unless one can adequately protect the hip while the patient is going about on crutches, it is better far to maintain the recumbent posture in bed with weight and pulley. If deformity has already arisen, then there is still greater need for the bed-treatment, because an inclined plane can be employed, and in this way traction can be made in the line of deformity.

The question often asked by physicians, when to put on a splint, may be answered—just as soon as you can fit a splint to the patient. This does not mean as soon as you can fit the patient to the splint. Time in bed is not time lost. The splint, therefore, can be used in any stage—can be used just as soon as the disease develops and before any deformity arises—but it should meet the indications: it should protect the joint against the trauma of accident and the trauma of reflex muscular spasm; it should hold the limb taut, therefore, and the weight, if the patient walks, should be transferred either to the axilla or to the perineum.

Fig. 340.

Thomas splint applied.

Among the splints which require axillary crutches are the plaster-of-Paris splint, which is shown in Fig. 338, the Willard, seen in Fig. 339, the Thomas splint, Fig. 340. The Willard splint can hardly be employed, however, as a fixation splint unless the joint be done away with. Dr. Willard himself employs it in convalescing cases. But with the joint locked it serves a very useful purpose. Its construction is very simple, as it is made over a cast. The Thomas splint has a very extensive use throughout Great Britain. It is a simple posterior splint, but requires rather nice adjustment if it is to be at all serviceable. None of the splints thus far mentioned are used for traction purposes.

Orthopædic surgeons generally favor traction. In my own practice I employ traction wherever it is possible to do so, but I find it necessary frequently to omit the traction and employ simple fixation; for instance, where the limbs are excoriated from adhesive plasters or where the

symptoms are very acute. In hospital practice, where the instrument-maker is always at hand and where the patients are under daily observation, I find it necessary frequently to omit the ordinary traction splint in very acute cases, and employ until these symptoms have subsided some form of fixation.

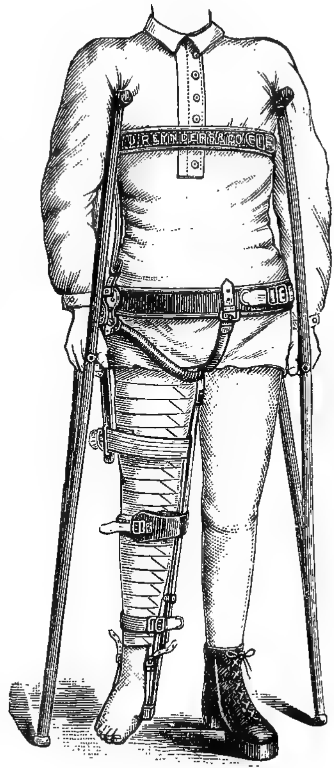
Among the traction splints may be mentioned the long traction splint fully illustrated in all text-books and the Phelps splint. There are many varieties of the splint first named, the long traction splint, but all embody practically the same principles that the first splint was intended to embody. All are modifications of the Davis splint. The short Sayre splint is on the same principle.

It is difficult to estimate the value of the long traction splint; it is equally difficult to decide upon its disadvantages. As a means of relief from pain and as a comfort to a child afflicted with hip disease its value can certainly not be over-estimated. To one who has observed for a number of years suffering in all stages of hip disease from the painful spasm, from distorted limbs, from confinement to bed and crowded wards, a splint which enables the child to get up and out of doors, to walk on the perineum, and to play with other children seems an inestimable boon. Too much, however, is claimed for the splint. It is claimed, for instance, that if properly applied it will not only prevent deformity, but correct deformity. It is claimed that the long splint itself, in conjunction with an inclined plane, is amply sufficient to correct the larger number of deformities that occur at the hip. On the other hand, there are very good men who claim that it is not competent to correct deformity, and is not competent to prevent deformity. It is a useful instrument in a large proportion of cases. The protection it affords the joint by reason of the traction enables the patient to lead an out-of door life without the aid of axillary crutches, and where it is applied before deformity occurs an intelligent surgeon, with any kind of home co-operation, can certainly prevent deformity, as a rule. In dispensary practice this home co-operation is so difficult to get that one sometimes despairs of conducting the average run of hip disease to a successful issue. Deformities do occur with the long splint, and it is exceedingly difficult to prevent deformity even after it has been corrected. In private practice I am sure that much better results can be obtained. The ideal hip-splint has not yet been invented.

The Phelps splint is claimed by its inventor to not only prevent deformity, but to secure absolute protection to the joint, and in this way it is thought to meet all the indications required. Yet the proof is thus far wanting, in my opinion, that this splint will do what is claimed for it. It certainly has certain advantages over the long traction splint, and they are these: it immobilizes the joints above and below the hip-joint, thus preventing any muscular action which would distort the hip; it distributes the weight between the perineum and axillæ, or, rather, it relieves the perineum of the weight of the body and transfers it nearly all to the axillæ. One feels, however, that if the hip can be managed without the use of axillary crutches and without immobilizing the lower part of the spinal column, the treatment can be made much easier for the patient and much less annoying to the parents. The Phelps splint is illustrated in Fig. 341.

An important question which one is called upon to decide is, How long must the splint be worn? If a case can secure the advantages of the long traction splint before the stage of deformity—that is, the first stage of the disease—it requires from one to two years' continuous use of the splint to effect a cure. I have never felt that one could get the best results by using a splint by day and weight and pulley at night. The child should sleep in the apparatus. Care should be taken to see that good traction is made, especially at night, and maintained throughout the day. If the use of the splint is begun after deformity has arisen, in the second stage, the time requisite for the best result is from three to four years. It is in this stage where abscess is likely to occur, where already important changes have taken place, not only in the head of the bone, but about the joint itself. The process of resolution is exceedingly slow. A splint is applied in the third stage very often after the correction of deformity, by some surgeons before deformity is corrected, and it is in this stage that it is difficult to name any time for the wearing of the splint. If one is satisfied that the disease is fully arrested, the splint need be worn for from six to eight months after the correction of deformity. Convalescing splints are employed toward the close of treatment. There is no question more difficult to decide than when a good protection splint may be dispensed with and a convalescing one substituted therefor.

FIG. 341.



Phelps's combination traction hip-splints.

The ordinary tests of cure are unsatisfactory at best. Many orthopædic surgeons of very large experience claim that there is disease present so long as reflex spasm exists, and there are many surgeons who are never able to decide when reflex spasm ceases. About the best test, in my own experience, is that which was formulated by the late Mr. Hugh Owen Thomas—namely, the test of function. His plan was to remove the apparatus when he felt that the joint had been protected a sufficient length of time and when there were no inflammatory products to be recognized about the hip. At the end of a week he made another examination, and if he found that the range of motion had increased, he was positive that the disease was fully arrested. If, on the other hand, the range of motion had decreased, the splint was reapplied, and he felt sure that longer protection was required. In my own practice I employ at the period when Mr. Thomas would remove the apparatus a convalescing splint, which is a splint that does not employ traction, that gives motion at the hip, knee, and ankle, and is really the Dow's splint of Taylor.

This apparatus has served me a very good purpose, and, while it is true that circumstances sometimes compel me to return to the protection splints, in the majority of instances this necessity does not arise.

In closing these remarks on the use of apparatus I wish to guard my readers against the improper use of the adhesive plasters, and to dwell upon the necessity for protection of the knee-joint during the entire course of treatment. In employing adhesive strips for traction the plasters should be long enough to extend from the upper third of the thigh to a point about two inches above the malleoli. Not only should the plasters be this long, but the surgeon should see that they adhere closely to the thigh, so that too much traction may not be made upon the knee-joint itself. As a result of the improper application of plasters and of the failure to protect the knee I have seen great laxity at the knee-joint, and a very marked recurvatum develop toward the close of a long course of splint-treatment. The Judson knee-piece, which is well known now among orthopædic surgeons, is a U-shaped steel support which is attached to the stem of the splint and affords ample protection to the knee. After a case has been cured it is necessary to occasionally observe the patient, so as to protect him against these later deformities at the knee.

For the correction of deformity various methods are employed. The most common is traction, either by means of the splint or by means of weight and pulley on an inclined plane. For this purpose it is better to have the patient in bed, or at least in a recumbent posture. In place of the bed a wheeled chair may be employed if the proper framework is attached to the chair. That which seems to me the best kind of apparatus is the Cabbot frame. After using various appliances of this kind I find that I get best results with this modified frame. The weight over the foot of the bed is difficult to keep in good position; it does not contribute to the cosmetic effects of the sick-room, and especially in a hospital ward it has the appearance of cruelty; hence I have for a long time now employed the windlass at the end of the inclined plane. I can thus get any amount of traction I choose. If I want elastic traction, the elastic pieces can be attached to the stirrup and thence to the adhesive strips on the limb. Counter-extension is afforded by the pelvic band. It must be borne in mind that traction must always be made in the line of deformity. After a week or two the plane can be lowered, and so on until the deformity is fully corrected.

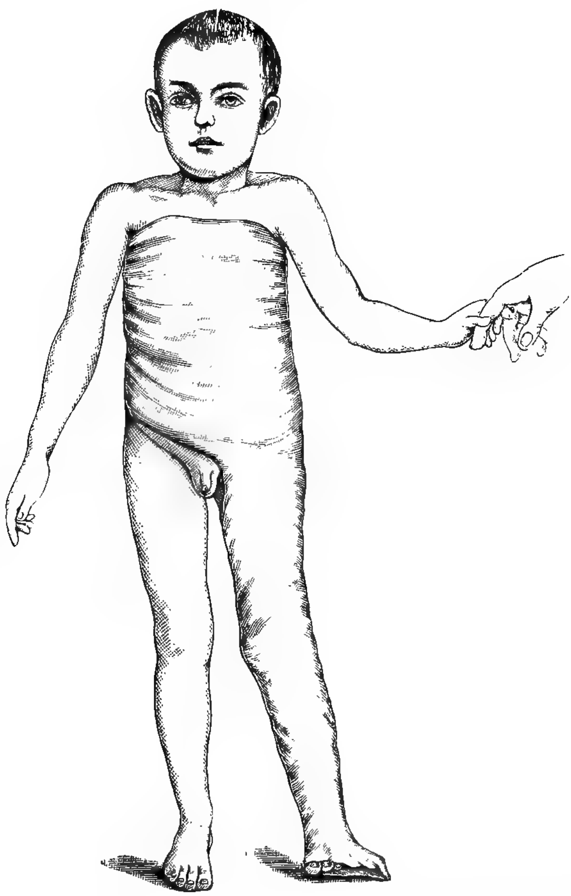
If one cares to use the hip-splint, the whole limb encased in the splint can be put upon this inclined plane, and by means of the rack and pinion attached to the splint sufficient traction can be made.

Where this means fails, manual force, supplemented by subcutaneous myotomies, can be employed, the deformity partially corrected, and a plaster-of-Paris bandage employed, followed by rest in bed for one or two weeks. Then the process can be repeated, and so on until the deformity is overcome. It must not be understood that by manual correction is meant *brisement forcé*. This term as employed in surgery carries with it the idea of forcible movements in flexion and extension, and has been employed in connection with the treatment of ankylosis. Manual force, therefore, means careful manual force—a steady pull in the line of deformity, accompanied by a gradual extension.

When these means fail an osteotomy below the trochanter minor is a

most excellent method of treatment. This operation is easily performed, and with a novice should be done by the open method. If one is skilled in subcutaneous surgery, a small osteotome, quite sharp at its edges and rather narrow, can be easily inserted through the skin down to the periosteum, and the bone severed throughout nearly the whole of its thickness. Then a little manual force employed will serve to complete the solution of continuity. A simple fracture will thus be produced, and a plaster-of-Paris bandage from the axillæ down over the hip to the foot makes the best dressing for a fracture of this kind that can possibly be devised. I speak advisedly on this subject, because I have employed the plaster with such uniform success. If one, however, is not familiar with the use of plaster, as has been remarked before, then a long side splint from the axilla to the foot, with the limb and body securely bound to the splint, and this supplemented by traction with weight and pulley,

FIG. 342.



will make a very safe dressing. Fig. 342 is a very good illustration of a limb that has been corrected and encased in plaster of Paris.

My plan is to put the child to bed immediately after the plaster is set, and at the end of two weeks use a wheeled chair ; at the end of six weeks remove the plaster, when union is, as a rule, found very firm. While the patient is waiting for an apparatus to maintain the good position, for some months afterward I employ weight and pulley in bed. The apparatus I employ is a spinal brace with a stem running down over the hip to the lower third of the thigh. A lever is thus secured for the limb ; the fulcrum is just back of the trochanter major, and the whole apparatus can be secured more accurately by means of a roller bandage. If one finds it difficult to apply the bandage properly, a canvas lacing can be made, which will answer an admirable purpose. Axillary crutches are now to be used for a few weeks, these finally abandoned, and the difference between the limbs made up by a high shoe. I have found it necessary to employ this apparatus for a period of from six to twelve months to guard against relapse. In volume vii. of the *Transactions of the American Orthopædic Association* I have recently published a paper on this subject—a paper which is well illustrated.

Operative procedures on the hip include evacuation of abscesses, excision of abscesses, the curetting of sinuses, the gouging out of foci of disease in the bone, partial arthrotomy, excision, and amputation.

In the treatment of abscess one must be guided by the general condition of the patient and by the location and severity of the abscess. By the condition of the patient is meant either an excellent condition of health or a very much impaired condition. If the former, there is really very little occasion for operative interference, for the reason that the abscess is not acute, and that many abscesses in patients in good condition of health undergo absorption and finally disappear. There are some surgeons who believe it wise to evacuate every abscess, but these surgeons are in the minority and belong to what is known as the bolder class. The more conservative surgeon, no matter how successful he may be or how good his judgment, does not look upon a cold abscess as at all detrimental to the health of the patient or as interfering with the ultimate recovery of the bone whence the abscess comes.

If the patient is in poor health and the abscess seems, after a little observation, to be an important factor in perpetuating this ill condition of health, then it is the duty of the surgeon to dispose of it as early as possible.

The location of the abscess has much to do with whether it shall be left alone or treated surgically. For instance, if it is in the way of the proper adjustment of a protection splint, then interference is called for. If it encroaches upon the deep femoral vessels, it is well to interfere. If, again, the abscess is specially large and is increasing rapidly, so that a large area of tissue in the gluteal region or in the upper part of the thigh is involved in the dissection of the abscess, then operative interference is called for. It should be borne in mind, however, that a great many abscesses open spontaneously and that excellent results follow, while an equally large number, after a spontaneous opening, go on to further suppuration, progressive exhaustion of the patient, finally the development of amyloid degeneration of liver and kidneys ; which degeneration of itself is, as a rule, fatal.

The operative procedures are—simple aspiration ; aspiration followed

by the injection of some aseptic agents, such as carbolic acid, creasote, iodoform, and iodine; simple incision, the opening being large enough merely to permit of escape of the contents of the sac; free incision; free incision followed by dissection or complete destruction of the sac itself. This latter may be followed by exploration of the bone-focus and removal of all the diseased material in the bone.

After a very extensive experience in the management of abscesses by means of the aspirator and the aspirator combined with injections of various kinds, my preference is largely in favor of simple aspiration. I make this statement, notwithstanding the increasing testimony in favor of injections of various agents, because at the hospital I have analyzed from time to time a series of cases treated after the various methods, and the best results, I am sure, are attained by simple aspiration. This plan of treatment has become so popular with me that I make it a rule to subject all abscesses to aspiration.

When the sac is filled with extensive sloughs of cellular tissue, which sloughs plug up the needle at every insertion, I resort to incision, provided the location of the abscess is favorable for incision. I am not quite sure but that a small incision in a large number of cases, with pretty free irrigation of the sac and an antiseptic dressing, is better than the free incision. It is certainly better than the free incision unless the latter is attended with a thorough dissection of the walls of the sac. Where one is prepared to carry out all the details of thorough dissection of the sac I would advocate this plan for the class of cases which may be described as follows: an abscess that has existed for a long time, say several months, that has made little or no increase in size, and that contains pus either too thick for an ordinary needle or contains a cheesy mass; a very large abscess which has burrowed extensively and encroaches upon important structures, such as the blood-vessels, or that interferes with the proper application of the splint; an abscess which is attended with a daily rise of temperature and that is interfering with the nutrition of the child. Such abscesses as I have just described are suitable, in my judgment, for the treatment proposed. It is very easy to dissect an abscess, to sew up the wound, and to get primary union, but if one fails to follow up the track and remove the bone, the chances are that at least 50 per cent. will recur and that subsequent openings will have to be made. While I have no figures bearing on this subject, my hospital experience enables me to make this statement thus approximately. Did space permit, I am sure I could report a number of cases which go to bear me out in this opinion.

The treatment of sinuses is a most perplexing one, and I am free to say that, at present, I have no specific to commend. The various agents for closing a sinus are all commendable, yet time and again I have regretted closing a sinus, for the reason that the pus must find exit, and there is no better way for the pus to escape than through one or two of these old sinuses. After the discharge become insignificant, then the curetting of the sinus may be adopted, this curetting to be followed by thorough flushing, and the injection of peroxide of hydrogen or creasote or iodoform and oil.

The removal of foci of disease in the bone is certainly to be commended in many cases. If one can be satisfied that the focus can be

reached without too free gouging of the joint itself, then one's duty is clear. The trouble, however, is that there are many foci, and the removal of one does not relieve the others. On the contrary, it is well established that an incomplete operation serves sometimes to disseminate the bacilli and to rather aggravate the original disease. The plan of drilling the neck through the trochanter major promised brilliant results a few years ago, but experience has shown that the disease is not always confined to the neck, or even the epiphysis, and for this reason the operation has not been so extensively resorted to within the last few years.

The operation of arthrotomy or partial artheotomy is more especially applicable to the knee, and has never gained many adherents where the hip is concerned. The simple removal of the synovial sac and the soft structures, even the cartilage lining the acetabulum and covering the head, does not reach the seat of disease, and when one goes thus far it is regarded as the part of prudence to remove the head of the bone.

Excision of the hip is an operation that is called for in a certain proportion of cases. A very thorough study of the subject has not inclined me to early excision, but the cases for this are those which have failed to improve under the protection splint, under good hygienic surroundings, and which seem to go from bad to worse. Statistics bearing upon the subject are of little value, for the reason that most men make a selection of their cases and final results are difficult to obtain. The brilliant work of two London surgeons a few years ago led us to believe that a thorough aseptic excision, with complete removal of all diseased structures, could be done, and that primary union would result. Subsequent teachings and subsequent observation of the cases operated upon in this way lead us now to believe that the ideal method has not been attained. If one excises early, he is bound to get a large number of good results. If he excises late and as a dernier ressort, he is bound to get a large number of failures ; but, after all, the failures can scarcely be regarded as failures, because these cases were necessarily doomed and the excision was a life-saving method. It is a fact well established that hospital and dispensary cases demand excision much more frequently than those in private practice. The former class usually occur in children of shiftless parents—parents who are poorly trained in the sense of co-operation, and who have never learned to set any correct value upon the splint treatment ; while in private practice the surgeon, as a rule, has intelligent co-operation. He has more time to instruct the families, and in addition to this the parents themselves enjoy better hygienic surroundings.

The question of what incision is the best for an excision is largely a personal one, and must always depend upon the individual judgment of the surgeon. Where the bulk of the suppuration is in the gluteal region or posterior aspect of the thigh either the incision of Sayre or the straight incision posteriorly is recommended. Where the bulk of the suppuration is in front, however, the anterior incision is by all means preferable. I have long since abandoned the saw, and the chisel and gouge are used exclusively in excision of the hip. With curved scissors and forceps as supplemental instruments all the diseased tissues can be easily removed. For the reason that a focus is usually found in the trochanter, it is best

to remove this portion of the bone as well as the neck. Furthermore, better drainage is afforded, and the ultimate function of the joint is not impaired by removal of the trochanter. Where one is satisfied that all the diseased bone has not been removed, the larger part of the wound should be left open and further drainage established. The limb may be put up in a wire cuirass or on an ordinary Thomas hip-splint with traction by weight and pulley. On account of the ease with which I can employ plaster of Paris, I dress most of my cases with a firm plaster-of-Paris bandage, applied from the free ribs to the ball of the foot, making a snug fit just above the condyles and above the malleoli. A fenestrum is cut in the plaster, and through this the wound can be dressed as often as is necessary.

It does not follow because a hip is excised that the treatment has been exhausted. If, for instance, the treatment should seem to fail of good result and the suppuration should persist, it is the surgeon's duty to follow the operation up with further procedures, draining pockets where found, freshening up old sinuses, removing any bits of bone that may be retained by the healing process. In other words, the case should be conducted to a successful issue if this is possible. The results are very gratifying in properly-selected cases. Even in cases that are operated on as a dernier ressort brilliant results follow.

It is the practice of many surgeons to omit apparatus as soon as the sinuses are healed or even long before this period, yet I am forced to believe it unwise, for the reason that deformity is apt to recur many months after the closure of all sinuses. Flail joints are sometimes reported after the operation, but I am convinced that they are rare. Such a result can only follow a very extensive removal of the shaft of the bone. Removal of the shaft is sometimes required where there is an extensive osteomyelitis. The propriety of thorough curetting of the medullary canal is questionable. A bone that is so thoroughly diseased as to require this procedure would be better treated, in my judgment, by a complete removal of the member, although from the reports of Dr. Charles T. Poore of this city good results have followed curetting. In my own experience I have had no such results. Destruction of the acetabulum, iliac abscesses, extensive disease of the ilium, are not contraindications to the operation, because all disease can be removed and good drainage can be established.

Amputation of a hip is called for when the entire shaft of the femur is diseased, where a thorough excision has not only failed, but is followed by amyloid changes in the liver and kidney, and where all diseased processes cannot be removed in any other way. The proportion, of course, of cases for amputation is small, but yet indications do arise for this extreme measure, and the life of a child should not be abandoned when there is a possibility of saving it by amputation.

Minor Diseases of the Hip, including Congenital Dislocation.

Under this heading may be included periarthritis, periostitis of the shaft near the hip, synovitis, bursitis, neurosis.

A periarthritis is usually phlegmonous in character, proceeds rapidly to deformity of the joint, produces constitutional disturbance which is

entirely different from that produced by chronic ostitis of the hip, and runs a comparatively short course. The diagnosis can be made with comparative ease, generally by exclusion, and the treatment should be rest in bed and hot fomentations; these failing, there should be free incision. The abscess is always an acute one and demands the ordinary surgical procedures.

Periostitis is a little more difficult of recognition, is essentially chronic, and a diagnosis may be reached by exclusion. Palpation is an important method of examining. The existence of localized tenderness and swelling about the bone itself, with the history of an injury, goes to make up the essential features in the diagnosis The treatment is protection to the joint—for the reason that the head and neck may become involved by contiguity—blisters to the parts or some other form of counter-irritation. Really the best method, however, is a free incision down to the bone, with an opportunity of the parts to heal from the bottom.

Synovitis of the hip is very rare, but is occasionally met with. It occurs in children from ten to fifteen years of age. It is acute, invasion is sudden, and the entire course does not extend over a period of ten weeks. The joint-tenderness is very marked. The patient after the first twenty-four hours is unable to walk. The flexion of the limb comes on early, within the first few days; the entire limb is held with a great amount of care. The diagnosis is reached by exclusion. There is a certain degree of tension in the gluteal region. The distention of the joint can be made out by close manual examination. There is absence of the ordinary signs that accompany a chronic disease. The treatment is rest in bed. The limb should be maintained in that position which is the most comfortable. Fomentations may be applied, or fly blisters. Aspiration or puncture of the joint is not called for, for the reason that there is nothing to gain specially by rapid removal of the fluid. It is absorbed within two or three weeks, and the recovery is perfect.

Bursitis is met with occasionally in the bursa in the gluteal region, about as frequently in the bursa on the outer side of the hip under the vastus externus. Such cases occur usually either after twelve years of age or in early adult life. They date from an old strain or injury of some kind. There is very little atrophy of the limb. There are long periods of remission without any signs worth considering, no very acute symptoms even during exacerbations—simply a little lameness, disability, dread on the part of the parent and family that serious mischief will follow. A careful examination of the parts, with a clear insight into the history, will enable one usually to recognize these inflamed bursæ, and treatment will depend a good deal upon the severity of the case. The mechanical appliance which has proved serviceable in my own hands is a simple straight splint attached to a pelvic band, with or without motion at the joint—without motion at first, later with motion, giving simply a hinge-jointed movement. This splint must extend down to the shoe, with a free joint at the knee and a free joint at the ankle. It can be secured to the limb by thigh- and calf-bands and by a perineal strap to the pelvic band. This splint prevents rotation of the limb, and in this way affords rest to the parts under the vastus externus. It is applicable, therefore, for inflammation of this bursa. In a number of instances I have aspirated the bursa and made compression, only to get temporary

relief. In one instance I dissected out the bursa, with subsequent use of an apparatus, and finally got a good result.

Neuroses of the hip are so intimately associated with the hysterical element that hard-and-fast lines of treatment cannot be laid down. They are interesting simply from a diagnostic point of view. The diagnoses are usually easy, because of the age at which the deformity occurs and of the general neurotic condition of the patient. The deformity is usually that of flexion and adduction. The lameness is very marked at times. There is a good deal of hyperæsthesia along the course of the anterior crural or sciatic nerves. There is spinal tenderness, as a rule; absence of joint-tenderness, though sometimes this may be present; absence of atrophy of the limb. In hysterical subjects, therefore, the treatment should be adapted to the hysterical condition, yet it is true that counter-irritation of the spine and in the course of the distribution of nerves does bring about sometimes brilliant results. In the neuroses which depend upon exposure to cold in children past the tenth or twelfth year there is nothing quite so good as a fly blister to the lumbar spine. This should be applied at night, should be two inches in width by six inches in length, should be left on all night. The blistered surfaces should be dressed for three days every six hours with hot flaxseed poultices. I am thus dogmatic on this question, because I have seen many brilliant results follow this line of treatment. In fact, it is the exception that a good result has not followed.

Congenital Dislocation of the Hip.

This is a deformity for which very little has been done in the way of mechanical appliances. It is true there are a few cases on record wherein long persistence in the use of traction and reposition of the limb has resulted in what seems to be a prominent reduction of the deformity. The very nature of it would seem to be an insuperable obstacle to a cure by mechanical devices. We have not only an ill-shapen head of the femur, but usually the neck is distorted as well. A portion of the acetabulum is wanting. Nature has failed to make a proper receptacle for the head. During the early years of life use of the limb favors shortening of important muscles about the hip. The capsular ligament is altered in shape and in structure, so that, however well we may succeed in pulling the limb down into position, there is nothing that will hold it in place so well as a good rim to the acetabulum.

It is unnecessary to go into further detail about the etiology and pathology of congenital dislocations of the hip, because all the text-books on surgery and all the treatises have dealt so fully with the subject. I have for a long time entertained the opinion that a long traction splint, with a rigid pelvic band, under the daily observation of a well-trained nurse for a period of from two to three or four years, will result in a small proportion of cures. I have effected one such myself, but the time that has elapsed since the removal of all apparatus is not yet sufficiently long to enable me to predict the end-result.

We come, therefore, to the operation which has found such able exponents in Dr. Albert Hoffa of Wurzburg and Dr. Lorenz of Vienna. Their operations differ really very little in essential features. Hoffa's

operation is a posterior incision, straight one; Lorenz's is an anterior. Both aim to get to the joint and expose the acetabulum with a minimum amount of difficulty. The structures to be divided are about the same. Bradford of Boston has made a suggestion—and, indeed, has acted upon this suggestion—which is certainly a very important supplement to the operation of Lorenz. He has found that division of the Y-ligament enables him to bring the head of the bone down into normal position without such extensive division of the muscles attached to the shaft. The cardinal point is to make a sufficiently deep acetabulum, and one in which the head of the bone will lie easily without traction. Traction, of course, is to be employed in the subsequent treatment. The wounds should heal promptly, and the cicatrix that results will assist in maintaining the head of the bone in position. From a limited experience in the operation I am convinced that it requires a great deal of dexterity, and that a large number of operations must be performed before one can feel justified in making a good prognosis. It is a tedious operation, an enormous amount of violence is done to the tissues, and the shock is necessarily great. The results, so far as I have been able to observe them, are not brilliant and are rather discouraging. I make this statement from my own experience. Both Lorenz and Hoffa speak very enthusiastically of the operation, and record what seem to be excellent results. The procedure, therefore, is at present *sub judice*, and it is unwise to make any extravagant statements until more final results can be obtained. Among some cases of my own, recently published, I procured photographs of a case before and after operation. The deformity in this case was overcome; the limb was held in good position up to the time of the patient's discharge, which was six or eight months after all wounds had healed.

As a rule, young children, under the age of three years, are better cases upon which to operate. After the ninth or tenth year has been reached it is difficult to obtain a good result.

The deformity itself is not a hideous one where both hips are involved. The gait is sometimes rather graceful. I am convinced that it can be improved upon by a certain amount of attention and education. Where one side is involved a high shoe can make up the difference and a very easy gait can be attained. It is true, we have the limp, yet the little patient can walk long distances and can indulge in all the plays that other children enjoy. It is the exception for any painful conditions to follow in after years. Such an exception I have recently had under observation, but relief was afforded by a snug abdominal bandage, which made very good pressure over the hip. Spinal braces accompanied by perineal straps really do very little, but these are recommended by some authorities, and in obstinate cases, where the operation is not to be considered, are advisable.

Tubercular Ostitis of the Knee.

The most frequent and most important disease which affects the knee-joint is the one which heads this section. The synonyms are—White swelling (tumor albus), Strumous arthritis, Scrofulous knee, Fungous arthritis, Articular ostitis, and Tubercular ostitis. Really, the best term

for popular use is white swelling. Following the plan already set forth, the term tubercular ostitis fixes the pathology upon one's mind and carries with it a pretty intimate knowledge of the nature of the disease. The etiology and pathology have already been discussed.

Clinical History.—The disease belongs essentially to childhood, and the ages between which it is most common are two and ten. The first symptoms noted are pain on handling the limb and on using it in walking, and the signs are extra heat over the knee, with slight reflex spasm when flexion approaches the limit. It is usually the frail member of the family that is affected. The first impression is that an injury has been sustained, and it is easy to get a history of a trauma as the cause; yet, as in the other joints discussed, trauma is found on cross-examination to play a very unimportant part in the etiology.

The child favors the limb in walking a little—complains of a little stiffness. A sprain or twinge of rheumatism or the beginning of a bad habit is diagnosticated by the family. The exacerbation, like that where other joints are involved, may be very slight and may extend over a few days or a week. Then a remission occurs, which is regarded by the parents as complete. Surgical or medical services are not usually sought in these milder cases until the second or third exacerbation appears. The limb during this first remission appears to be normal, but if one were called upon to make an examination it would be found that the function was not quite as good on the affected side as on the sound side. The contour of the joint, it is true, would show very little change, but to a critical eye the depression on either side of the tendon of the quadriceps would be less pronounced than in the normal condition. The ligamentum patella would appear a little broadened. In the midst of the exacerbation there often is a moderate distention of the synovial sac, and the case looks at this period very much like one of acute synovitis, but the history of the former exacerbation and of a remission would enable one to rule out acute primary synovitis. Yet it is true that this diagnosis is more frequently made than any other. If the patient be subjected to treatment during this second or third exacerbation, while the signs are not very pronounced, rest in bed will relieve to a certain extent, and a remission less pronounced than the former ones may follow. The epiphyses gradually become enlarged, the function of the joint is impaired, and the first stage, which is the stage preceding deformity, merges gradually into the second, that of deformity.

Deformity is characterized by slight flexion and marked change in contour of the limb; that is, increase in size with obliteration of the normal depressions. The lameness now persists, and is so uniform in character that a knee-limp is easily recognized, the limp characterized by a short step, a disposition to walk on the toe and ball of the foot, to lean to that side and favor the limb.

Atrophy is an early sign, and persists throughout the entire course of the disease. Exacerbations are induced by trauma, and deformity, such as subluxation or luxation, is the natural result of the use of the limb, aggravated by the reflex spasm of the flexors. There are various grades, dependent more or less upon the number of foci. A focus may exist in the head of the tibia, and very little deformity will result. It may be confined to the lower epiphysis of the femur, in which event deformity

is more apt to follow. It is possible for the disease to extend over a period of years and still produce very little deformity; yet the rule is to have a peculiarly shaped limb, such as has been described, and which is so well shown in most of the text-books and brochures on this subject. The third stage is marked by luxation or subluxation, by a bulbous appearance of the lower end of the femur, enlarged veins, and abscess which may have opened spontaneously or been incised, leaving sinuses. Where resolution takes place only the deformity will remain, but where the disease progresses from bad to worse there will be extensive suppuration about the knee, in the thigh, and in the calf. The suppuration will finally have its effect upon the constitution—emaciation, amyloid changes in liver and kidney, etc. etc.

Pain is not a persistent symptom, but is present in all exacerbations; it is very severe when an abscess has just begun to form, especially if the abscess be deep-seated and the pus presses upon important structures in its attempt to get to the surface.

In an analysis of 300 cases, made in 1893, I found that 140 had abscesses, 160 never had abscesses at any time; 40 died. The cause of death was tubercular meningitis in 6; exhaustion after prolonged suppuration in 14; phthisis in 3; dysentery in 2; amyloid degeneration in 2 only; and 12 of this number from intercurrent affections which had no connection whatever with the disease; 1 died from shock after an excision. With 22 deaths as a direct result of the disease we have a mortality of 7½ per cent.

Diagnosis.—From the clinical history the diagnosis should be comparatively easy. It is not difficult if one makes a careful and comparative examination of the limbs. The same remarks apply with equal force to diagnosis here as in affections of the hip and spine. In making a differential diagnosis one must be able to rule out acute primary synovitis, a severe strain or contusion, a periarthritis, a rheumatic arthritis, a bursitis, derangement of the cartilages, and neurosis.

An acute synovitis is very distinctive. The synovial sac is distended with fluid, and no other parts of the knee, such as the sides and posterior aspects, are involved. There is a certain amount of flexion dependent upon the amount of fluid in the knee. There is a history of a trauma, usually in close relationship with the symptoms. It is true a synovitis may be but an expression of an exacerbation, and it may appear during the first exacerbation. In this case a differential diagnosis cannot be made at a single observation.

Severe strain or contusion is attended with signs of injury to the soft parts, such as laceration of the skin, ecchymosis, and superficial swelling. It of course has the history of injury immediately preceding or preceding by one or two days only. If the deeper structures are involved, the diagnosis must be made by exclusion; that is, one must exclude a dislocation of the semilunar cartilage, a detachment of some of the fibres of this cartilage, a chipping off of the patella or the tibia about where the ligamentum patella is attached.

A periarthritis is usually a cellulitis, involves the soft structures, is often phlegmonous in character, and need not depend upon trauma as a cause. It is acute as a rule. The remarks just made apply to the

periarthritis as it occurs in children. In adults we have a rheumatoid or rheumatic periarthritis, which involves the capsular ligament and the structures intimately surrounding the joint. If one can feel a distinct grating like that of rice-bodies or sand as the knee is flexed and extended, a diagnosis of rheumatic periarthritis can be easily made. If the signs just mentioned are absent, then the case will require a little closer observation. Examination of the urine will sometimes assist in completing the evidence in the case.

Rheumatic arthritis is usually associated with a periarthritis, but may be entirely independent of any periarticular lesion. The sensation imparted to one's hand as the limb is moved is significant, and if to this be added a similar sensation in other joints, especially the other knee, ostitis can be easily eliminated.

The bursæ about the knee are not infrequently involved in a subacute form of inflammation, depending upon trauma and occurring usually in ball-players or athletes generally. The bursa in the popliteal space is sometimes affected by a sharp flexion of the limb, and a severe concussion or bruising added to this. The diagnosis is made when such is the case by a careful comparative examination of the limbs, by close attention to the history given, and by the absence of signs pointing to a lesion in the joint or in the parts in the anterior surface of the limb. A rare form of bursitis occurs in the bursa between the ligamentum patella and the top of the tibia. This can be made out by a comparative examination and by a process of exclusion. The bursa between the quadriceps extensor tendon and the thigh has a communication with the joint itself, and it is difficult to dissociate the bursitis here from an arthritis. If this bursa can be made out very much enlarged and the joint itself proves to be very slightly affected, then one can easily speak of a bursitis in this locality. Where other bursæ are involved it is more than likely that they must be associated with a general arthritis or periarthritis.

By derangement of cartilages is meant either a luxation or a subluxation of the semilunar cartilage, varying in degree and including lacerations of the posterior or anterior attachments. A complete dislocation of the semilunar cartilage is so rare that an extended description is unnecessary. The subluxated semilunar cartilages are most frequently met with, and are produced by a sharp flexion of the knee with a rotation inward or outward. If outward, the internal semilunar, if inward, the external semilunar, cartilage is slightly displaced. If one can examine shortly after the trauma which is nearly always the cause, the cartilage itself can be recognized lying along the upper border of the tibia, and can be brought out in relief by sharply flexing the knee while the examination is made. The existence of tenderness along this line, with the absence of tenderness in other parts of the joint either within or without, enables one to make a diagnosis. If the examination is not made shortly after the original injury, but at a later period, one must look for a history of exacerbations, and the patient will usually describe certain slipping sensations when the limb is flexed, associated with internal or external rotation. It must be understood also that these exacerbations are attended with a limited area of arthritis, sometimes periarthritis. If this is understood, then the significance of the arthritis

can be properly estimated and the essential points of the diagnosis be established.

Loose bodies may be classed under internal derangement of the knee. These are known as loose cartilages sometimes, and occasion often a rather acute attack of arthritis. They slip about just as a semilunar cartilage does, with the exception that their location is different. The sensation of the patient can be relied on a good deal in making a diagnosis, for the bodies themselves can be distinctly felt at times.

The neuroses of the knee are characterized simply by an absence of any physical signs other than a flexion. This flexion is clearly due to spasm of the hamstring group, and is associated with irritable spine. The points brought out in differential diagnosis of the hip are applicable to the knee quite as well.

"Charcot's knee," as it is called, is associated with tabes dorsalis, and may in the earlier stages present signs that will be extremely confusing. The extreme laxity of the joint-structures with lateral deformity, sometimes marked subluxation and even luxation, are characteristic signs in the tabetic joint. Occasionally an extreme degree of hydrarthrosis is present.

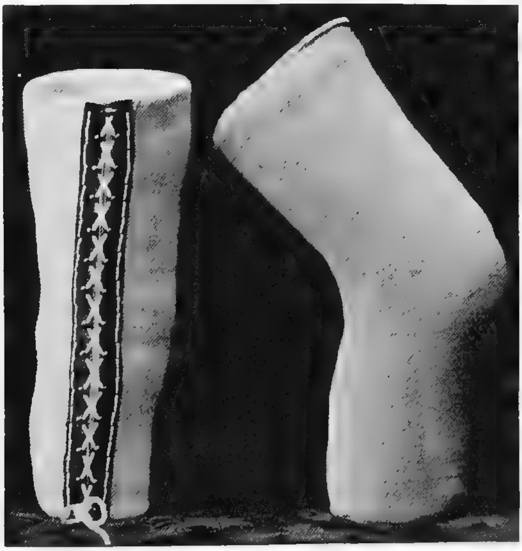
In enumerating the points in differential diagnosis no reference was made to sarcoma. It is just as well, however, to include this in the differential diagnosis. In sarcoma the bony enlargement extends some distance above or below the joint, and is really a sarcoma of the femur or of the tibia. The joint itself participates only secondarily, yet so long as it is involved the signs are those of osteo-arthritis. One predominant feature is continuous boring pain. To this is added a slow growth, with often a pulsation imparted to the hand. This pulsation is almost pathognomonic of sarcoma. While it is not present in all cases, when found it is of great value.

Treatment.—To successfully cope with tubercular ostitis of the knee one must be prepared to carry out the most efficient protective measures over a long period of time, as well as to interfere with operative procedures when occasion demands. The treatment, therefore, is mechanical and operative. The term "expectant" is very often used, meaning the treatment without resort to operation, but in the broader sense of the term "expectant" operations are frequently demanded. For example: The term itself means to treat symptoms and signs as they arise, to combat abscess, deformity, and destructive bone-changes. The aim is to conduct the joint through the different stages of disease to the best possible function, such as a good range of motion and freedom from shortening and deformity. The surgeon, therefore, who treats a case expectantly must not only prevent the reflex spasm which is an important element in the causation of pain, but resort to the correction of the deformity by manual force, mechanical appliances, or the knife, saw, and chisel. The better division, therefore, to make, in my judgment, is mechanical and operative. At the same time, it must be understood that one supplements the other—that even after operative interference mechanical appliances are to be employed, that the best possible results of the operation may be attained.

Splints of various kinds are used to immobilize the joint. Immobilization of itself is a very important element in the management of

ostitis, but rest to the articulation is quite as important. We speak, therefore, of fixation and rest as necessary to adequate protection. To fix a joint so that no motion can take place, and yet allow the patient to bear the weight of the body upon the foot, is, in my opinion, a very reprehensible treatment in the acute stages of an exacerbation, and—as exacerbations are frequent and come on with very slight provocation—it is unsafe to rely upon periods of quiescence during which the joint may not need rest. The trauma that comes from use is the chief cause of exacerbations, especially when fixation is employed. The trauma that comes from reflex spasm, of course, is quite as baneful as the trauma from use. To be more explicit: Let us assume that a case comes under treatment in the early stage, the stage just prior to deformity. The simplest form of treatment is a snug plaster-of-Paris bandage from the upper third of the thigh to the lower third of the calf, applied over a snug-fitting stocking or over a simple cheese-cloth bandage. The plaster should not be made removable unless one desires to employ counter-irritation, which, by the way, is sometimes a very good adjunct to the treatment by fixation and rest. The patient should either be confined to a bed or a wheeled chair, or allowed to use axillary crutches with a high shoe or patten on the foot of the well side. Where there is much pain on one or the other side of the knee the Paquelin cautery should be employed two or three times a week. In this case a plaster splint may be made such as is shown in Fig. 343,

Fig. 343.



Plaster knee-splints.

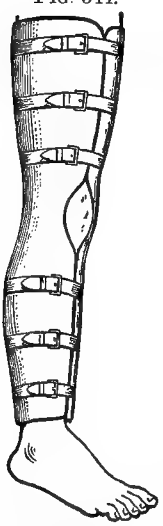
which represents a side and front view. This splint can be easily removed and reapplied, and is secured, as will be seen, by a lacing over shoe-hooks. Adhesive strips of plaster can be employed in place of shoe-hooks, or straps with buckles.

The plan just detailed can be made efficient throughout the entire course of the disease, assuming that the case has come under observation in the early stage. It can be employed even in later stages with great advantage. Other measures are needed, such as correction of deformity, the different procedures for the treatment of abscess, arthrectomy, the removal of foci, etc. etc.

A popular impression, which is shared to a great extent by the profession as well, is that fixation of a limb in plaster of Paris or any splint or dressing which immobilizes is sure to result in ankylosis, and one, therefore, who may resort to the method just described will encounter throughout the entire course a most obstinate ankylophobia in the parents, as well as in the physicians who may come in contact with the case. This one fact has within the last few years been most fully established—namely, the best way to prevent ankylosis is to secure the most perfect immobilization in a joint near which or in which disease exists. Time and again I have heard surgeons of large experience give advice like this in the consulting-room: "Put the limb in plaster, and let the patient get ankylosis as soon as possible." Ankylosis results from incomplete immobilization and poorly-fitting splints, because the inflammatory products that result from the trauma of muscular spasm and from use produce periarticular as well as intra-articular adhesions. I have myself on many occasions observed inflammatory products about a joint undergo resolution under absolute immobilization conjoined with rest.

Inasmuch as many are not accustomed to the use of plaster, other forms of fixation may be mentioned, such as posterior splints of leather—an example of which can be seen in Fig. 344—of wood, of steel bars on either side of the limb, joined at top and bottom by bands which partly encircle the limb and are secured in position by roller bandages. Such a brace is known at the hospital as the Knight knee-brace, and is a very serviceable splint. The various forms of traction apparatus, such as the Sayre splint and the various ones of the shops, which are largely figured in all the text-books, may be used if care is taken to apply them so that protection is ample. The splint which has proven most valuable in my own hands is the Thomas knee-splint, which is shown in Fig. 345. This is, in fact, an ischiatic crutch, and when supplemented by fixation of the joint really meets all the indications for an ideal treatment. The patten or high shoe should be at least three and a half inches in height. Four or four and a half is preferable, even if it be necessary to employ ankle-supports on the high shoe. The late Mr. Thomas himself insisted always on a very high patten, for the rea-

FIG. 344.



Leather knee-splint (Marsh).

FIG. 345.

Thomas's knee-splint.

son that the foot on the affected side would not touch the floor, and as the child grew there would be no danger of the splint growing too short between the dates for observation. A knee thus protected really requires very little attention. The parents can be easily instructed in the ordinary details of home-management. In private practice objection is often made to the height of the shoe, and to obviate this I have had the splint made extensible. In order to prevent the toe touching I have employed a pretty taut check-strap between the bars just back of the heel. This check may be of leather and broad enough to prevent the heel from resting on top of it. The ordinary leather trough, as figured in the cut, was regarded as all-sufficient by Mr. Thomas, because he bandaged the knee back into this trough and secured a very fair degree of immobilization. I have found plaster of Paris much more serviceable and much more reliable.

Convalescing treatment, which should not even be suggested until after all inflammatory signs have disappeared from about the knee and until a small range of motion has been secured, is this same splint with the foot-piece cut off and the ends of the stems turned at right angles so as to make a caliper splint. These turned ends of the stems are inserted into a hole through the front part of the heel of the shoe. The high shoe is, of course, discarded now, and the patient is sufficiently protected against traumatic influences.

In my analysis to which I have made reference (the paper was published in the *American Journal of the Medical Sciences* for October, 1893) the very best results were obtained by the Thomas splint conjoined with fixation by plaster of Paris.

The occurrence of abscess is not by any means a bar to the treatment now under discussion. On the contrary, the abscess cases are almost as easily managed as those in which abscess has never occurred. For instance, I find this paragraph in my résumé: "By the protective plan where abscess occurred (19 cases), 16 had motion and 3 were ankylosed. Where abscess did not occur (18 cases) all had motion, none were ankylosed."

The deformity can be corrected by various forms of apparatus by the simple use of plaster of Paris. A snug-fitting plaster bandage can be applied to a knee in a high degree of deformity. The patient can be allowed to walk about on a pair of axillary crutches. At the end of a fortnight the plaster can be removed and a little better position will be found—that is, less deformity; plaster again applied, and so on until very nearly all deformity will have disappeared. This is rather a slow process, but is one that is safe, and in a certain proportion of cases efficient. An excellent method is weight and pulley in bed on a double inclined plane. I have seen acute-angled deformities overcome within a few weeks by this method, and with very little pain or discomfort attending the whole process of correction. The posterior splint of Knight is applicable to a certain number of cases. This splint, it must be understood, relies for its efficiency on the proper use of the roller bandage.

The Billroth splint, which is very similar to the sector splint of the late Dr. Stillman, is about the best means for correcting the average deformity with which I am familiar, or it may be that I have used this to the exclu-

sion of many others on account of its simplicity and general applicability. I shall take the liberty of presenting a quotation from a paper published in the *Medical and Surgical Reporter* for June 9, 1888 : "The method may be described as follows: Two fan-shaped pieces of tin or steel, each applied to an iron bar, are connected at the smaller expansion by a joint. One fan-shaped piece fits the outer surface of the thigh, the other the outer surface of the leg, the joint being at the knee, a similar instrument being applied to the inner side. The whole is of very simple construction, and can be made by yourself or by any smith. The leg is then covered by a skin-fitting stocking or flannel bandage; some turns are made around the limb with the plaster-of-Paris bandage; then this instrument is applied and covered with the plaster of Paris. The lower part of the patella, bordering on the ligamentum patellæ, should be left exposed, not covered by the plaster. The bandage should be applied very thickly in the popliteal space. The limb should be put up in the position you find it, without any extension being made. While the cast on the leg is still damp take your knife and make a transverse section of it down to the skin through the popliteal space. This completes the first dressing. The patient should now be allowed to go home, and the cast to become completely hardened before you do anything further. After twenty-four hours, and from day to day—if necessary from week to week—you can proceed to straighten the limb with manual force by degrees, maintaining what you gain at each visit by inserting a piece of cork between the divided portions of the plaster cast in the popliteal space. A piece of adhesive plaster passing over the cork to the cast on either side will retain it in position."

After the knee has been brought to about 175° it is difficult to effect further correction without the employment of more force than is usual, and my plan is to employ a solid plaster-of-Paris bandage at this period, making a little extra extension while the plaster is setting. The limb, once straight, is very easily treated by the use of the Thomas knee-splint.

The operations for the correction of deformity are manual force under an anæsthetic, division of hamstring tendons conjoined with manual force, osteotomy above the condyles, cuneiform osteotomy through the joint, and excision of the knee. The operations for the removal of disease are curetting; gouging out of foci, which is known as partial arthrectomy; complete arthrectomy; which is removal of all the soft structures which go to make up the joint, supplemented by removal of any foci that may be within reach; and excision of the knee.

My experience in correcting deformity by means of mechanical appliances under an anæsthetic inclines me to a preference for the correction under manual force, supplemented by division of the hamstring tendons subcutaneously. For one who prefers mechanical devices for this purpose the genuclasts of Bradford and of Goldthwait of Boston are specially recommended. An illustration of the Bradford genuclast is furnished in Bradford and Lovett's work on *Orthopœdic Surgery.* The treatment of abscess is based upon the same principles as those depending upon disease of the spine and disease of the hip.

The indications for arthrectomy are not always clear, for the reason that extensive suppuration is often relieved by curetting and by the

proper protection of the joint. The advantages offered by arthrectomy when excision is contemplated are that the function of the joint may be retained or restored and that shortening of the limb will not result. In my own practice I very seldom have occasion to even recommend arthrectomy, because of the uniformly good results which can be obtained in children, and because in adults excision seems to me to offer certain advantages.

Excision is done most frequently in adult patients, and the operation, when done thoroughly, gives a very useful limb. It is difficult to lay down any hard-and-fast rules for excision, but it is certainly a good operation to recommend for tubercular disease of the knee in adult patients or in patients who have passed the age of childhood, especially if they belong to the poorer classes. Where one can afford the time and the expense of a prolonged course of mechanical treatment, and where the case is not complicated by severe pain or deep-seated suppuration, a successful result can be attained by efficient mechanical appliances. A case, however, which has had inadequate protection during the first year or two of the disease and has gone through various methods of treatment imperfectly carried out should really be treated by excision. There are in all large cities a great number of unsteady, painful knees in which disease has existed for many years, and where various futile efforts have been made to secure a useful limb. Such cases exist largely among the poor in the laboring classes, and it is idle to talk about treatment with apparatus. It is not necessary to wait for an abscess in such cases, but once the diagnosis is established and the conditions above stated found to exist, then the sooner the operation is done the better.

Prognosis.—In children a good result can, in a large proportion of cases, be secured. By "good result" is meant a straight limb, very often a knee with the functions very nearly restored, arrest of all disease, no shortening, and little if any lameness. It is the exception to have shortening in this disease where deformity has been prevented, or where it has been corrected early and a good position maintained until all symptoms and signs have subsided.

In the paper to which I have already made reference my analysis showed that motion was obtained more frequently in those treated by the protection plan. In 16 of the cases where abscess occurred there was, as final result, 90° of motion, while in those where abscess did not occur 25 could be moved voluntarily over an arc of 90°. Relapses are not very frequent, and of all the cases, whether they recovered with motion or without, 150 out of the 300 presented subluxation of the tibia, against 48 where there was no subluxation. Only 2 of the whole number presented complete luxation. In 183 cases where the condition of the patella was noted, 124 gave a movable patella, while in 59 there was no motion. Out of 227 cases analyzed so as to bring out the position of the limb, 15 got well with deformity at an angle under 135°, and 141 presented an angle of deformity of not less than 165°. They were enabled, therefore, to walk with limbs practically straight and with scarcely an appreciable deformity: 71 of these could extend their limbs to an angle between 175° and 180°. These results, understand, are from cases treated by all methods except extensive operative

procedures. By comparing the different methods, however, the protective treatment, which included rest as well, gave the largest percentage of good results, while the fixation came next, and the expectant gave the smallest percentage.

Minor or Non-tubercular Diseases of the Knee.

1. Acute Arthritis of Infancy.

The most important of these diseases is the acute arthritis of infancy. This has also been styled acute epiphysitis and acute osteomyelitis. It occurs in very early life, sometimes in a few weeks after birth, more frequently within the first year of life. It begins as an acute process, attended by marked constitutional disturbance, and soon resulting in extensive suppuration with great deformity. The diagnosis can be easily made by comparing these rapid changes with the changes which take place in a chronic tubercular ostitis. Again, the age of the patient is against a tubercular lesion. The treatment is surgical from the beginning. If hot fomentations and rest fail to give relief within the first week, then the abscess should be freely incised, its depth noted, any broken-down bone removed, and all the parts thoroughly drained. At the same time, the limb should be brought into normal position and retained by a firm dressing, and nothing has appeared quite so satisfactory to me as the plaster of Paris. Where such prompt measures are not adopted the case usually proceeds from bad to worse, and the end is either a fatal result or a flail joint which troubles the patient throughout life. I do want to emphasize, again and again, the necessity for prompt surgical measures.

2. Periarthritis.

Periarthritis is phlegmonous in childhood, while in adult life it is simply a subacute or chronic inflammation of the deeper structures surrounding the joint, and is associated frequently with rheumatism. The diagnostic points have been mentioned already in discussing the differential diagnosis of tubercular ostitis, so that a repetition is unnecessary. The treatment, however, calls for rest when it is phlegmonous, with resort to the knife if resolution does not follow promptly; while in adults, especially if it be rheumatic, motion should be enjoined. If adhesions have formed and a stiff joint results, then attempts should be made to correct under an anæsthetic, at the same time preserving whatever motion is gained. This brings one to the discussion of ankylosis in general. Suffice it to say, that a joint that is very firmly ankylosed from periarticular adhesions is exceedingly rare. There are also intra-articular adhesions, which make a restoration of function exceedingly difficult. Where osseous union between the patella and intercondyloid space is believed to exist I favor open incision and a separation of this union. The subsequent treatment is massage, the douche, and active and passive movements.

3. Rheumatic Arthritis of Knee.

Rheumatic arthritis is one of the most common affections of the knee in adult life. It frequently depends upon a trauma of some kind, and it

is only after the disease is developed that a rheumatic element is discovered. The diagnosis has already been under discussion. The treatment may be outlined in the following quotation, which I take from a paper recently published in the *Denver Medical Times* for January, 1895: "In summing up, therefore, the treatment of a chronic or subacute rheumatic knee, I would say that use in the early stage is good, but let the patient understand that the motion is not to be forced—that if he finds flexion beyond a certain range painful, let him avoid this test. For the night-pains hot fomentations are good. For pains that persist throughout the day the Paquelin cautery has, in my hands, proved most efficient. Where the traumatism induces an exacerbation, rest in a plaster-of-Paris splint for a few weeks is eminently proper, but on the subsidence of the pain the limb should be used up to the range of tolerance. The use of adhesive plaster has, in my hands, been of great service. The advantage, I think, which this has over the silk elastic knee-cap or any kind of knee-cap is that the pressure is made directly over the parts infiltrated, and does not completely encircle the limb, thus interfering with the return circulation and impairing more or less the tissues below, so that I seldom ever use an elastic knee-bandage in rheumatic knees. I sometimes use a canvas knee-bandage which is laced up along the inner side, and under which can be placed cotton-wool for more equable pressure. Where the ankle is involved as well I use a good deal the stockinet bandage. My chief reliance, however, is in the brace, which is to be worn until complete convalescence is established."

4. Internal Derangement of Knee.

One of the most common internal derangements of the knee is a displacement, more or less complete, of the semilunar cartilage. This injury results from a sharp and sudden flexion of the knee with rotation inward or outward. Where the rotation is inward, the internal semilunar is subject to a sharp separation of some of its fibres of attachment, permitting a slight slipping or a complete slipping of the cartilage, which makes a dislocation of the same. Where the twist is external the external semilunar cartilage suffers in the same way. The pain is quite severe. The patient feels a slipping of some kind, and naturally either extends the limb or gets some one to extend it fully and make traction. This procedure often results in a replacement of the cartilage. If this could be followed, now, by protection to the parts for a reasonable length of time, say a fortnight, all acute symptoms would subside and the result would be perfect. But it is not usually thus followed by any protection; the patient continues to use the limb, and an arthritis by contiguity is set up as a result of the repeated traumatisms. When the case comes under the care of the surgeon he usually finds a general arthritis, and it is difficult to detect the real starting-point of the lesion. A history will usually be afforded of subsequent slippings, and an examination, with this history, made with the knee flexed, will enable one to determine the ridge along the upper border of the head of the tibia, which ridge of the soft parts is caused by the projecting semilunar cartilage.

The **treatment**, as has already been suggested, is protection to the parts, preferably in a plaster-of-Paris bandage, with the knee fully

extended. The patient should use axillary crutches for two or three weeks, or even longer if the symptoms persist. A snug-fitting, plaster-of-Paris bandage, however, for two or three weeks in the majority of cases will be all that is necessary for such firm protection. On the removal of the plaster the external parts should be strapped well with strips of rubber plaster, and the patient should be cautioned against bending the knee until all symptoms have completely subsided. If the case is one of long standing and comes under the care of the surgeon during one of the relapses, then something more than the above precautions is necessary. In my own practice I have found a splint, such as has been described in the preceding pages in the treatment of rheumatic knees, most efficient. The range of motion is limited for a few months.

The operation for removal of the cartilage or for exposing it and anchoring the torn edges by sutures has proven very successful in the hands of some surgeons, but as a general surgical procedure it is not usually recommended. At least, it ought not to be recommended until other measures have failed—measures such as have been already described. The operation itself is simple enough. One can easily reach the offending body, can expose the parts fully, and can suture the cartilage to the head of the tibia by silkworm gut or even good sterilized catgut. One of the main contraindications for the operation is the existence of other loose bodies in the knee complicating the displaced semilunar cartilage.

Loose bodies in the knee, known as loose cartilages, may arise from hydrarthrosis or from acute attacks of rheumatism. These bodies can be easily felt and the diagnosis is not very difficult.

The **treatment** is mechanical and operative.

The chief form of mechanical appliance is an elastic bandage about the knee, or laced knee-cap, as it is called, which serves to fix the loose body in some one particular part of the joint where it is innocuous.

The operation consists in crowding the cartilage toward the surface, where it can be felt directly under the skin—a free incision thereover, with enucleation of the body. This operation, simple as it may seem, is not always successful, but is sometimes attended with a pretty sharp attack of arthritis, followed by adhesions and fibrous ankylosis. It is one of the recognized operations, however, in surgery, and is to be performed under strict aseptic precautions by a surgeon who has had a reasonable degree of familiarity with joint surgery.

5. Bursitis.

A not infrequent injury about the knee may be traced to an inflammation of the bursæ. On page 349 injury to the bursæ has been discussed in making differential diagnosis of ostitis of the knee. For diagnosis, then, one can refer to this section.

The **treatment** involves a period of rest to the joint, accompanied with strapping of the bursa when not too acutely inflamed. If the latter be the case, hot fomentations are eminently satisfactory. The prepatellary bursa is the one most frequently affected, and is known as "housemaid's knee" or "devotional knee." Here we have often a good-sized tumor which requires tapping or excision. Generally tapping, with firm compress

immediately following, is sufficient to effect a cure. In some instances, where the inflammatory area has extended not only about the joint, but into the joint, a posterior splint, or even a plaster-of-Paris bandage, is regarded as a valuable adjunct. Other bursæ about the joint are not usually subjected to operations, because a knowledge of the existing conditions will enable one to adopt expectant measures for relief.

6. Neurosis.

For neurosis of the knee the same principles in treatment may be adopted which have been already outlined in the section on neurosis of the hip. (See page 345.)

7. Charcot's Knee.

For tabetic knee or Charcot's joint we really have little in the way of treatment. It is interesting simply from a diagnostic point of view, and curative measures are yet to be suggested for this extraordinary disease.

Ostitis of the Ankle.

The synonyms are—Caries of the ankle, Tuberculous ankle, Tubercular ostitis of the ankle, White swelling of the ankle, Chronic synovitis. The disease itself is characterized by impairment of motion, pain on use, reflex spasm, bony enlargement, destruction of bone, destruction of the joint-surfaces, abscess, and deformity generally.

The etiology and pathology have already been discussed. It remains now to note the clinical history.

Clinical History.—The invasion of this joint by disease is very similar to the invasion of other joints. The patient favors the foot in walking. One can easily recognize the ankle-limp. We have the characteristic exacerbations following upon trauma—extra heat about the bony prominences, preferably the malleoli, sometimes the head of the astragalus, sometimes the scaphoid. The contour of the joint is soon changed, so that a comparative examination will enable one to detect filling up of normal depressions, exaggerations of bony prominences, atrophy of the calf, and increasing disability. Later we have abscess, which is attended usually with severe pain enormously aggravated by use. The abscess may be multiple, and the whole joint may be ultimately riddled with sinuses. The history of ostitis of the ankle differs a little from that of the knee and hip in that resolution in children is sure to follow, and that complete destruction of the joint and death from suppuration are the exceptions. It is a curious fact that the farther removed that a tuberculous joint is from the centre of circulation the better result we may expect. In the ankle, for instance, a child may go through all the stages of this disease, extending over a period of from two to five years, may be subjected to various kinds of treatment irregularly carried out, and will, as a rule, make a good recovery—a recovery which enables the child to walk without lameness and to have very nearly normal use of the foot.

Ostitis of the ankle as it affects adults is altogether a different disease, and radical measures are much more frequently demanded. The course is by no means benign. It is difficult to secure adequate pro-

tection to the ankle in an adult, and for this reason expectant treatment is, as a rule, unsatisfactory.

Diagnosis.—A number of lesions about the ankle, such as periarthritis, sprain, synovitis, teno-synovitis, unreduced subluxations, simulate ostitis of the ankle, but a careful comparative examination of the parts will enable one, as a rule, to detect localized areas of inflammation; for example, over one or the other of the malleoli, over the bones of the tarsus; reflex spasm, atrophy of the calf. These signs, taken in connection with a satisfactory history, enable one to differentiate this disease from any that have been named. It is unnecessary, therefore, to go over the points in differential diagnosis.

Treatment.—The management of a case depends largely upon the age at which the disease develops. If it occurs in a young child under four years of age, fixation of the foot in a skin-fitting plaster-of-Paris bandage, with strict injunctions against walking, will suffice to bring about a very satisfactory result. This treatment must extend over a period of twelve months at least. If abscesses have already formed, these may be aspirated, or, if the aspiration fails, incision may be made and foci of bone, which can be reached through the incisions, removed by the spoon. Fenestra can be cut in the plaster, so that immobilization can be continued, or the plaster itself may be cut down in front and made into a splint. In lieu of the plaster, wire or leather splints may be employed—anything, in fact, which secures adequate immobilization. If the child is over four years of age, or even over three in some instances where it is desirable to have the child walk, a splint may be employed very much like the Thomas knee-splint, with a patten or high shoe on the sound foot. The weight is thus transferred from the sole of the foot to the perineum, and the child will soon learn to walk about very comfortably. Where a light support, such as plaster or leather or wire cast, is not used to immobilize the foot, a sliding foot-plate should be applied to the Thomas knee-splint, near the lower end, and in that way the foot can be kept at right angles, thus affording all the protection that is required. In older patients, adolescents and adults, immobilization supplemented by axillary crutches will give relief in a certain number of cases. Where, after a reasonable length of time, this treatment proves valueless, operative measures should be instituted, such as removal of the astragalus, excision of the joint, or even, in desperate cases, amputation.

Such, in a general way, is the treatment for ostitis of the ankle. In children where abscesses form and burrow throughout the foot the management is often exceedingly difficult. If one is familiar with the clinical history, the temptation to excise or partially excise is not great. If the abscesses are properly drained and if the foot is kept in good position, recovery in a large percentage of cases will take place, with a useful foot—a foot on which the patient can walk with very little lameness and without a support. It is interesting to note, too, that a child may suffer from numerous abscesses about the ankle, the suppuration may not only be extensive, but prolonged over a period of years, and still the liver and kidneys will not be involved in amyloid changes. One need not, therefore, fear amyloid degeneration in a case of ostitis of the ankle in a child. Exhaustion is exceptional too, yet the surgeon

must be prepared to follow up these sinuses from time to time, afford efficient drainage, attend to the general health, encourage an out-of-door life, avoid too long confinement in hospitals, and even excise or amputate if the case should seem to demand so radical a procedure. In a word, then, a case must be managed on sound surgical principles. The surgeon must not take fright at the occurrence of numerous abscesses and sinuses, but must rely very largely upon the recuperative powers of nature. Excision of the ankle may be better studied in other sections of this work, and for this reason I have omitted any extensive reference to it in this connection.

Sprains.

The term "sprain" is used to designate a sudden rupture of the soft tissues immediately surrounding a joint, a stretching of these tissues without necessarily a rupture of any of the parts. The lesion, however, is followed by swelling, pain, ecchymosis, disability of the joint, and sometimes a deformity. A sprain varies in degree, and leaves one at a loss sometimes to decide just how much injury has been wrought. It is common to speak of rupture of ligaments or separation of the ligamentous attachments, but when such occurs the injury is very severe. Indeed, it is difficult to make out just whether a ligament is ruptured or not. More frequently some fibres of the tendon are torn in two or the bruising takes place about the insertion of the ligaments or tendons, which gives rise to the signs above mentioned. Ordinarily, acute sprains do not come within the scope of orthopædic surgery. A disability of the joint which has resulted from a sprain weeks or months previously often comes under the care of the orthopædic surgeon, because of this disability and because a cure has not been effected. The mode of production of this injury and the history of the symptoms and signs for the first few days are quite familiar to all medical men, hence details are unnecessary.

Diagnosis.—The diagnosis is very important, and it is difficult at times to differentiate a sprain from a fracture or a subluxation. The foot may be so distorted that one of the tarsal bones may project unduly and give rise to the suspicion of a dislocation. Again, the swelling about the malleoli may be so great that it is very difficult, by reason of the extreme tenderness associated with this swelling, to get a satisfactory examination. Ordinarily, however, the diagnosis is simple enough. A comparative examination of the ankles can be made, the functions of the joint tested, and a little manipulation is all that is necessary to detect crepitation. If it is impossible to get a satisfactory test by manipulation, then it would be better to treat the case as a fracture for a few days until the swelling shall have subsided, when the examination can be made quite easily.

Treatment.—In an acute sprain, or one that is seen even within a week or ten days after the injury, the plan which I have adopted with exceedingly gratifying results is the Cotterell dressing. I have already published two articles on this subject, the last one of which, in the *New York Medical Journal* for February 16, 1895, was fully illustrated. The details are as follows: After making the examination, employ massage for five or ten minutes with the foot well elevated. Next apply strips

of rubber plaster, about an inch in width and from twelve to eighteen inches in length, over the part sprained, beginning back of the injury. Aim to leave the part of the foot not affected as well uncovered as possible, but reinforce well as the strips are applied under the malleolus or malleoli. The first strip for a sprain of the external malleolus is applied, beginning just above the ankle on the unaffected side of the foot, and ending on the affected side about half the way up the calf. This strip is usually alongside the tendo Achillis and makes firm support under the heel. The second strip starts on the inner side of the unaffected part of the foot, near the ball of the toe, comes around over the back of the heel, and ends about the base of the little toe. It crosses the first one just above the border of the heel. The third strip overlaps the first halfway, the fourth the second, and so on until the part sprained is fully covered by this criss-cross strapping. A cheese-cloth bandage is applied, more with the idea of securing close adhesion of the plaster, and is removed within twenty-four hours. As soon as the dressing is completed the stocking and boot should be applied. The patient is now ready to begin walking, and this should be insisted upon in the presence of the surgeon. Direct him, for instance, to walk about the room eight or ten times. At first strong objections are offered, but after two or three turns it is asserted that walking becomes much more easy, and by the time the task is completed there will be very little lameness or disability. While it is undesirable to insist on too much walking for the next few days, it is essential that the patient should walk as much as it is necessary for him to walk—that is, attend to his business or any duties that require a moderate amount of walking. At the end of a week it is well to remove the strips and reapply in the same manner as above. Two or three such dressings suffice to complete the cure.

In old sprains a support must be worn for a much longer period, and where adhesions have already formed it has seemed to me that a plan which was recommended by the late R. O. Cowling, M. D., of Louisville, Kentucky, should be adopted before the strips are applied—namely, under primary anæsthesia move the foot about, break up the adhesions—produce, in fact, an acute sprain—and then treat this by the adhesive strips. Where one desires to raise the side of the foot a little, the sole of the shoe may be built up on that side from a quarter to three-eighths of an inch.

I have refrained from presenting the ordinary treatment by fomentations, plaster bandage, etc., because I found these methods very unsatisfactory, and because these methods are fully illustrated in all the textbooks of surgery. Incidentally, I have found adhesive strips very useful in sprains about the knee and other joints. Where the spinal column has been sprained, I have also used the adhesive strips with decided advantage.

Diseases of the Joints of the Upper Extremity.

The Shoulder.

Tubercular ostitis of the shoulder is rare in childhood, and still less frequently observed in adults. The lesions which are met most frequently are the results of old sprains of the shoulder, rheumatic periar-

thritis, and luxations. The diseases which the orthopædic surgeon is called upon to treat are ostitis of the shoulder, fibrous periarthritis the result of rheumatism or exposure, and congenital luxations and subluxations.

Ostitis is characterized by very nearly the same signs that one finds in ostitis of the hip or knee, such as reflex spasm, atrophy, limitation of movements, pain on use, extra heat. With a knowledge of these signs and symptoms diagnosis is comparatively easy. One naturally looks for an injury in getting the history, but if one fails to get a satisfactory explanation of the symptoms by reason of some trivial injury, it is fair to assume that an ostitis presents for consideration.

In the way of **treatment** it has for a long time been regarded as unnecessary to employ apparatus, for the reason that the weight of the limb itself is sufficient to produce the necessary amount of traction, and in this way bring about a cure; but in my own experience I have found the weight of the limb very unsatisfactory as a means of traction. Furthermore, the patient, who is usually a child, does not know enough to make use of the weight of the limb, and it is difficult to have any instructions bearing upon this subject carried out. The use of the shoulder is generally encouraged by some members of the family or by the family physician, so that the results are altogether disheartening. From a very extended experience I am convinced that traction apparatus should be employed if one expects to get a useful joint. It is comparatively easy to use a traction apparatus at the shoulder-joint and still have the use of the forearm. A leather-padded crutch-piece will rest in the axilla. To this a stem passing down the inner side of the arm, with rack and pinion, gives one an opportunity to employ as much traction as is desirable.

In cases of long standing, where abscess has formed, protection may still be employed with advantage, but the facility with which one can reach the focus of bone by a small incision is very encouraging for operative interference. An incision in front of the upper end of the humerus, just below the joint, down through the periosteum, should be made, and the periosteum dissected on either side about halfway around the bone. A drill now can be inserted into the bone, up through the epiphysis, the opening enlarged, and the entire head of the bone be removed by a Volkmann spoon, leaving the articular surface intact. At the same time, what adhesions exist may be broken up, the arm put at rest, and the wound treated either by drainage or by closure as one feels confident of his ability to remove every particle of disease. In the ostitis of adults, where suppuration has occurred and where extensive adhesion exists, I certainly favor excision. Indeed, the results of excision of the shoulder-joint are so satisfactory that the temptation to excise early is very great. In children, however, the growth of the bone by excision is interfered with, and hence the partial operation I have just described is more desirable.

In the rheumatic periarthritis of the shoulder, where the adhesions are slight and where the range of motion is only about one-half restricted, it is certainly better to break up these adhesions under an anæsthetic. The early use of the arm after the operation, say within two or three days, is necessary to secure the best result. Many of these cases, under the ordinary treatment of passive motion, massage, and active

exercises, make very slow progress, the patient suffers a great deal, and the final result is often a stiffish, painful joint. Where much inflammation exists around the joint I have employed with moderate success strapping of the joint and rest for a few weeks. After an improvement has been noted, then passive motion under an anæsthetic is called for. For the painful conditions which exist about the shoulder the Paquelin cautery, in my hands, has proved very efficient.

In the congenital deformities of the shoulder, after many failures with the usual methods of making traction, employing passive movements with or without an anæsthetic, electricity, etc. etc., I have come to the conclusion that it would be better to cut down upon the joint and aim to replace the head of the bone in the glenoid cavity—failing in this, to excise it.

The Elbow.

Tubercular ostitis of the elbow is occasionally met with. It is more frequent in children than in adults, and is often mistaken for the displacements of bone resulting from fracture. For the reason that serious results may follow very slight injuries at the elbow-joint it is difficult to rule out trauma as an exciting cause. If one is careful to get the history and makes a thorough examination of the elbow by comparing the salient points with those of the other elbow, it is not difficult to make a diagnosis. In fractures of the condyles or epicondyles, or even transverse fractures through the epiphysis, we have bony deposits resulting from unsuccessful efforts at reduction, and even in the successful cases we have often callus thrown out, which gives rise to many of the signs of an ostitis, such as bony enlargement, irregularity, impairment of function, pain on motion, extra heat, etc. Reflex spasm, a sign which is so valuable in diagnosis of other joints in the body, does not serve us a very good purpose where this joint is affected, because it is difficult to distinguish reflex spasm from the spasm of pain on motion and the patient's own resistance. A very good illustration of the appearance of an elbow which is the seat of ostitis is shown in Fig. 346. The degrees of ostitis of the elbow are almost identical with those of ostitis affecting the other joints: first, the stage without any appreciable deformity; later still,

Fig. 346.

Ostitis of elbow.

the stage of deformity with abscess; subsequently, the third stage of shortening and displacement.

The **treatment** is rest to the parts over a long period of time, maintenance of the limb in good position, aspiration or incision of abscesses as indications present; later still, if the suppuration persists, partial arthrectomy and excision. Excision is certainly a very satisfactory operation in the elbow-joint, and yields most gratifying results.

Deformities of the elbow which result from fracture and displacement may be treated by efforts at removing the displaced fragments, whether by passive movements under an anæsthetic or by incision upon the parts and removal with the chisel. A number of deformed elbows with callus interfering with flexion may be treated by repeated efforts at flexion and retention in plaster of Paris for a week or ten days after each minor operation. From a rather extended experience in the management of such cases I am satisfied that this procedure should be adopted before attempts are made to remove the bone by the chisel.

The Wrist.

Ostitis of the wrist with the consequent deformity certainly comes within the scope of orthopædic surgery. The principles which govern the treatment of ostitis of other joints are equally applicable here, and the foci of disease themselves can be the more easily reached if operative interference is required. These principles have been presented so fully in the preceding sections that it is unnecessary to repeat them.

ANEURYSM.

By LEWIS A. STIMSON, M.D.

THE word "aneurysm," derived from a Greek word signifying dilatation, has in the main preserved what appears to have been its primary signification—that of a hollow tumor whose cavity communicates more or less freely with the lumen of an artery, and into which, consequently, blood passes more or less freely from the artery. As clinical experience has increased, and facts ascertained upon the autopsy-table and in the laboratory have multiplied, the application of the term has been so greatly widened that it now includes arterial and even venous and capillary changes that have little or nothing in common with those that were primarily associated with it, and which cannot be included with them in a single definition. Nevertheless, excluding, on the one hand, certain pathological conditions known by specific titles, such as cirsoid aneurysm, aneurysm by anastomosis, dissecting aneurysm, and certain forms of arterio-venous aneurysm, and, on the other hand, certain changes too slight or too deeply situated to give any clinical symptoms, the term in its surgical acceptance indicates a condition that is perfectly well defined clinically and pathologically—that of an abnormal, local, circumscribed enlargement of the lumen of an artery with production of a (usually) pulsating tumor. This enlargement may have been produced gradually by the progressive stretching and yielding of the coats of the artery, or abruptly by the tearing or cutting of the wall of the artery, followed by the immediate escape of the arterial blood into the surrounding tissues, and the gradual formation out of the adjoining connective tissue of a circumscribed wall or sac continuous with the wall of the artery at the margin of the opening. The size and shape of the enlargement and its topographical relations to the artery also vary greatly, and out of these varied elements and the shifting views and theories that have been held concerning anatomical details and pathogeny has arisen a nomenclature that is now needlessly complicated and but ill adapted to the subject.

One of the earliest groupings was into so-called "*true*" and "*false*" aneurysms, including under the former term those aneurysms in which the continuity of all three coats of the artery was preserved throughout the dilated area, and under the latter term those in which the continuity of one or two of the coats was interrupted; and according as one or another of the three coats was thought to be absent varieties were described which we now know could have had no existence save in the imagination or the incorrect observations of the writers. Apart from the inappropriateness of applying the term "false" to the common typical form of a disease, it can now be said that the so-called "true" aneurysm, one in which all three arterial coats are present in all portions

of the wall, is not only very rare, but also that it exists only in the form of small irregularities in the wall of the aorta that are unrecognizable during life, and in certain moderate uniform dilatations of the large arteries (part of the so-called "fusiform" aneurysms) that give rise to few or no symptoms and are not amenable to surgical treatment. Most of these conditions have only a pathological, and no clinical or therapeutic, interest, and would be more fittingly grouped under the term *arteriectasis.*

Another condition upon which opinions have been divided, and of which the nomenclature has become greatly complicated, is that following a wound or rupture of an artery with free escape of its blood into the surrounding tissues. Among the terms in use are *traumatic aneurysm, ruptured artery, diffuse aneurysm, primary aneurysmal hæmatoma* (when it follows the rupture of an artery), or *secondary aneurysmal hæmatoma* (when it follows the rupture of an aneurysm). The difficulty is in part an academical one—one of definition; and in part it arises from varying anatomical conditions that depend upon the length of time that has elapsed in a given case since the rupture took place. When the condition is a recent one the anatomical conditions, the symptoms, and in most cases the treatment, are those of a wound of an artery, and are here described under that head; but in the older cases the conditions, symptoms, and treatment are essentially those of a spontaneous aneurysm, and will here be treated in connection with it. It must be borne in mind that aneurysms consecutive to a *partial* rupture of an artery—rupture of only one or two of its coats without an immediate escape of blood into the surrounding tissues—are included not among the traumatic, but among the spontaneous, aneurysms; indeed, it is rather widely believed that many, if not most, of the common aneurysms of the limbs are due more or less directly to partial rupture of the wall by overstretching of the artery where it crosses a joint or by bruising in its passage through a tendinous expansion. Such injuries and the resultant conditions are of course "traumatic," but custom limits the term to those in which the rupture has presumably been sudden and complete.

We have, then, to describe—

1. The common circumscribed aneurysm, including the so-called "true" and "false" aneurysms, traumatic aneurysm, ruptured or diffuse aneurysm, and fusiform aneurysm or aneurysmal dilatation;
2. Dissecting aneurysm;
3. Arterio-venous aneurysm, with its two varieties—varicose aneurysm and aneurysmal varix;
4. Cirsoid aneurysm.

1. The Common Circumscribed Aneurysm.

This affection appears to be much more common in some countries than in others, England being thought to have more in proportion to population than any other country. Dr. Eldridge[1] states that Europeans dwelling in Japan are affected with thoracic aneurysm to an extent very largely in excess of the proportions observed in any other country. The relative frequency in New York is indicated by the following statistics, taken from the reports of the New York Hospital for the years 1888–

[1] *New York Medical Journal*, February 10, 1894.

92: Of 22,197 patients admitted to the hospital during those five years, 55 were affected with aneurysm, divided as follows among the different arteries: aorta, 37; innominate, 3; femoral, 6; radial, 3; brachial, 1; and 5 cirsoid aneurysms. Of the 37 aneurysms of the aorta, 32 were in males, 5 in females; of the 3 of the innominate, 2 were in males, 1 in a female; all the others were in males. Other statistics, comprising a much larger number of cases, show the same predominance in males, and that the aorta, and mainly the thoracic portion, is much more frequently affected than any other artery. Such statistics include, in the main, only those cases that come directly under treatment, and but relatively few of the rather numerous aneurysms of the small arteries of the brain and of those in the walls of phthisical cavities in the lungs that are found post-mortem. So far as those aneurysms are concerned which are observed clinically, they involve the principal arteries in about the following order of frequency: First, the thoracic aorta (almost exclusively in its arch), then the popliteal and femoral, abdominal aorta, carotid and subclavian. The relative frequency of innominate aneurysm cannot easily be determined, for the differential diagnosis from aneurysm of the arch of the aorta is often impossible during life.

FIG. 347.

Periarteritis nodosa, or congenital aneurysms of a small artery of the mesentery (Eppinger).

Aneurysm is distinctly a disease of middle life, the great majority of cases occurring between the ages of thirty and sixty, or even thirty and fifty, years. Crisp's collection of 505 cases contained only one below the age of ten years, 5 between ten and twenty, and 16 above the age of sixty years. I have seen one case at the age of seven years, a delicate girl who had a large aneurysm of the right common and external iliac and a small one of the left femoral.

Aneurysms are usually single; occasionally two, three, or more coexist, and Pelletan reported a case in which 63 were found. A very few rare cases of multiple aneurysms of the smaller arteries have been described in detail by several writers, but under different names. Kussmaul and Maier[1] used the name *periarteritis nodosa*, and traced a connection between the affection and Bright's disease and progressive general muscular atrophy. Meyer[2] used the same name with the alternate "multiple aneurysms of the medium-sized and smaller arteries;" and Eppinger[3] gave them the name "congenital," to indicate,

[1] *Arch. für klin. Med.*, vol. i. p. 484. [2] *Virchow's Archiv*, vol. lxxiv. p. 277.
[3] *Arch. für klin. Chir.*, 1887, vol. xxxv., Appendix, p. 42.

not that they exist at birth, but that the condition of the arterial wall which favors their production does.

Etiology.—The immediate cause of the production of an aneurysm is found in the loss of the equilibrium between the distending action of the intra-arterial pressure and the resistance of the arterial wall, by which the former becomes predominant. This loss of equilibrium is commonly due to a diminution of the ability of the arterial wall to resist the normal blood-pressure, and only occasionally, if at all, to a temporary sudden increase of the latter. A number of cases have been reported in which the presence of an aneurysm has been noted immediately after the patient has experienced some strong emotion or made a violent muscular effort. Thus, Holmes[1] quotes two cases in which aneurysm of the abdominal aorta followed immediately upon the patient receiving sentence for a criminal offence.

The *predisposing* causes are general and local. Among the general causes are included those diseases, constitutional peculiarities, and habits which tend to diminish the elasticity and power of resistance of the arterial walls, such as syphilis, gout and rheumatism, and the prolonged habitual use of alcoholic beverages. Of these, the agency of gout, rheumatism, and alcohol appears to have been satisfactorily established through their effect in producing the changes known as atheroma and endarteritis; but the agency of syphilis is in doubt, both because clinical statistics do not support it, and because the arterial changes due to the disease are commonly manifested in the smaller arteries, where aneurysm is less frequent, and not in the aorta, where aneurysm is most frequent.

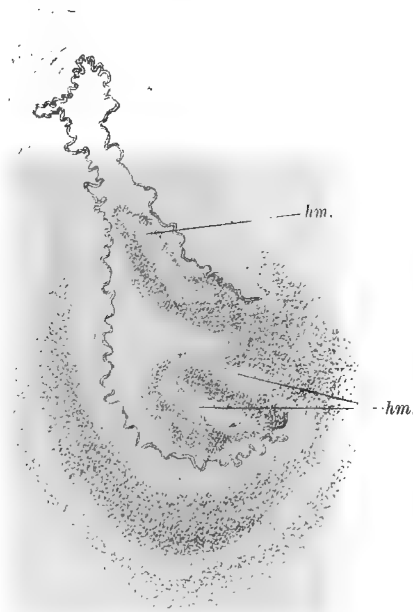
Among the local causes more or less certainly determined are anatomical peculiarities of the artery involved, such as its bifurcation, its change of direction, local alteration of the wall by disease, pressure, or an embolus, and injury of the wall by some form of external violence. The relative frequency of aneurysm of the common carotid at its upper end, where it divides into the external and internal carotid, is the only fact that can be quoted in support of the theory that the bifurcation of an artery is a condition favorable to the development of an aneurysm in its immediate neighborhood, and no satisfactory mechanical explanation of such alleged influence has been given. The influence of a change in the direction of an artery is thought to be shown by the relative frequency of aneurysm in the arch of the aorta, and the explanation is sought in the obstruction thereby offered to the flow of the blood through the vessel, and the consequent increase of the intra-arterial pressure at the points more directly impinged upon by the stream. As the same anatomical conditions exist in all individuals, while aneurysms exist in but few, it seems improper to speak of them as causative: some antecedent diminution in the strength of the artery is clearly necessary, and the anatomical condition can be causative only in the sense that by increasing the intra-arterial pressure at that point (if it does) less diminution of resistance is then required than at others.

A local change in one or more of the coats of the artery as the result of disease that diminishes its elasticity and strength undoubtedly precedes the formation of all the small "true" aneurysms and of most others. This factor in the pathogenesis of aneurysms has long been

[1] Holmes, *Syst. of Surgery*, Am. ed., vol. ii. p. 319.

positively known in connection with certain rarer forms of disease, acute or chronic, and has long been suspected in all except those in which sudden partial rupture of one or more coats by mechanical violence was the cause. Endarteritis, mesarteritis, and atheroma are the conditions precedent thought to exist in most cases; but the fact that they are relatively frequent, while aneurysm is rare, that they are most common and extensive in advanced life, while aneurysm is a disease of middle life, and that they are found almost as frequently in women as in men, while aneurysm is much more frequent in men than in women, show that their predisposing influence cannot be very great and that some other important cause must coexist. Probably the causative influence of these affections is much greater in the aorta and its large branches than in the other portions of the arterial system. Large atheromatous arteries are frequently irregularly dilated and tortuous, and atheromatous degeneration is habitually found in the old, and is often widespread and of long standing, and yet the vessels thus affected show little or no evidence of any tendency to the local circumscribed dilatation which constitutes aneurysm. In some cases a cheesy atheromatous focus in the wall of an artery opens and discharges itself into the vessel, and the blood entering into the cavity distends it and forms a sacculated aneurysm, or works its way along between the coats to break through again into the lumen of the vessel at a more or less distant point (dissecting aneurysm); but such cases are rare.

FIG. 348.



Mycotic-embolic aneurysm of a small artery of the pia (Eppinger).

Suppurative disease invading the wall of an artery from an adjoining abscess is claimed to have led to the formation of an aneurysm; but it seems more probable that in the few cases cited the artery has been perforated by the ulceration before the weakening of its wall has had time to end in an actual aneurysm, and the blood has then poured into the abscess through the opening and given it the appearance of an aneurysm.

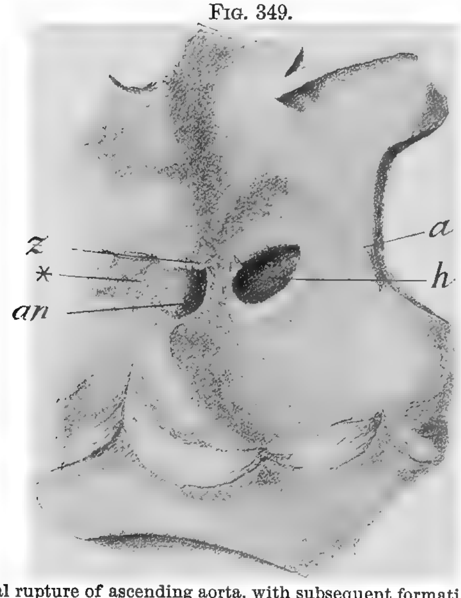
The effect of local inflammatory processes in the arterial wall due to microbic infection has been studied very carefully and in great detail by Eppinger,[1] using for the purpose specimens of infection of the wall from within by emboli coming from cardiac valvular vegetations due to endocarditis, and specimens of infection from without by the tubercle bacillus in the small arteries of the walls of the pulmonary cavities. In connec-

[1] Eppinger, *Arch. für klin. Chir.*, vol. xxxv., 1887, Appendix.

tion with the investigation he also examined several special forms of aneurysms produced in horses by the presence and growth of the parasitic worm *strongylus armatus*. In the first group of cases he found at the point where the infected embolus lodges (usually at the origin of a small arteriole of the pia) an acute exudative inflammatory process which involved all the coats, destroyed the tissue-elements, and brought about rupture of the intima and the elastic layer: this rupture of the intima and elastic layer appears to be the essential preliminary to the formation of the aneurysm, the wall of which is formed by the adventitia and, in very small aneurysms, by part of the media; the increase of the aneurysm is associated with recurrent acute inflammatory processes in and about the media in the neighborhood of the opening.

In the second group of cases, the small aneurysms of tubercular cavities in the lung, he found the inflammatory processes extending from the wall of the cavity, successively invading the coats of the artery from without, and followed by tuberculization. The formation and caseation

Fig. 349.



Healed partial rupture of ascending aorta, with subsequent formation of aneurysm: *an*, aneurysm (Eppinger).

of the tubercles produced rupture of the different elastic layers, and then, if the lumen of the artery had not been obliterated by the thickened intima and a thrombus formed upon it, the intima was pressed outward into the gap created by the rupture of the outer coats, and thus the aneurysm was formed. Similar observations were previously made by Meyer.[1]

The study of both forms shows that whether the change in the wall of the artery involves its layers successively from within outward or from without inward, the aneurysm does not form until after the elastic bundles within the media have been dissociated and the elastic layer on its

[1] *Arch. de Phys.*, 1880.

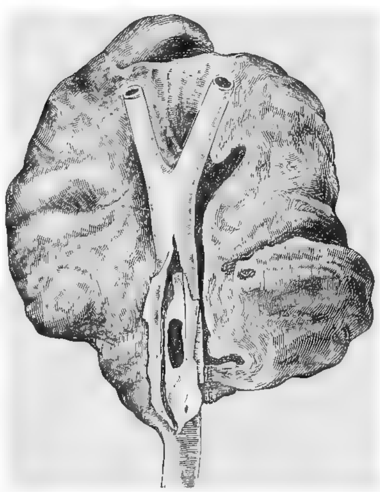
inner side ruptured. They indicate, therefore, that the media and the inner elastica offer the principal resistance to the dilatation of an artery, and that their rupture or their degeneration precedes the beginning of an aneurysm. This importance of the media has long been believed in on theoretical grounds, and its degeneration or its mechanical rupture has long been thought to be the necessary preliminary to the formation of an aneurysm.

Mechanical causes (excluding sudden complete division of all the coats) are seen in the cases in which an aneurysm has formed after the violent stretching of an artery by which its middle or middle and inner coats have presumably been torn, or after prolonged compression of an artery to cure an aneurysm at a lower point, or where an exostosis has pressed upon an artery. In the cases in which an aneurysm has formed at the point where a ligature has been applied to the artery we may assume that the reparative process has not been complete, and that the arterial cicatrix has yielded rather than the adjoining portion of the wall. An exceptional instance of the effect of pressure is the case reported by Castle, in which an aneurysm of the palatine artery appeared to have been caused by the pressure of a dental plate.

Pathological Anatomy.—We have to consider the sac and its contents and the changes produced in adjoining tissues by its presence and growth.

The aneurysm may be a more or less regularly ovoid dilatation of a portion of an artery continuous at each end with it (fusiform aneurysm), or it may be an eccentric pouch situated beside the artery and communicating with it by a lateral opening of greater or less size (sacculated aneurysm). This sac may be uniformly rounded, or may present one or more subordinate pouches due to its uneven dilatation or to rupture; it may vary in size from a diameter of a fraction of an inch to that of several inches. It is ordinarily a complete, well-defined membrane composed of the condensed and thickened connective tissue of the space through which its expansion has forced it, mingled in some cases with more or less of the original coats of the artery, according to its size or shape. Thus, in aneurysms in which the dilatation involves the entire circumference of the vessel for a considerable length, portions of the middle coat may be found at various points in the sac more or less widely separated from one another and degenerated: the lining membrane resembles in gross appearance the intima, and probably also contains portions of it. In the sacculated form of aneurysm the intima and media of the artery end abruptly at the edge of the opening, the neck of the sac; the intima of

FIG. 350.



Carotid aneurysm; artery laid open to show the orifice-(Scarpa).

the artery is continuous with a membrane of new formation that closely resembles it, but contains no elastic tissue, lines the inner surface of the sac, and often extends, by its endothelial layer, over blood-clots that have been deposited upon the wall. The adventitia of the artery is directly continuous with the condensed connective tissue that constitutes the main part of the sac. These anatomical conditions are the same even in purely "traumatic" aneurysms, in which the wall of the artery has been completely divided and the sac has been formed by condensation of the connective tissue crowded back by the escaping blood.

According to Thoma,[1] in the small "true" and "mixed" aneurysms of the aorta the sac is composed of all three coats of the artery, of which the intima and adventitia are increased and thickened by connective tissue, while the media is thinned and in places lost. Coarse ruptures of any of the coats are wholly absent, and he suggests the name of *dilatation aneurysm* (or aneurysm per dilatationem) as descriptive of the condition and mode of formation. He says the intima shows connective-tissue thickening, often with hyaline degeneration, calcification, and atheroma in the new tissue. The media is notably thinned, corresponding to the stretching, and in some places of greater distention it disappears, while the intima and adventitia remain unbroken. The primary change appears to be an arterio-sclerosis; then come the stretching and thinning; then a fibrous mesarteritis. In the larger aneurysms the connective tissue of this last process becomes very predominant. Then come hyaline degeneration, calcification, and atheroma. The adventitia is thickened, resembling cicatricial tissue (periarteritis). In the larger, ordinary aneurysms (for which he suggests the name *rupture aneurysm*) the media is ruptured; a new intima is formed, composed of connective tissue without elastic elements, and apparently having an endothelial lining derived by extension from that of the adjoining intima of the artery; the adventitia thickens and stretches. When perforation occurs it seems to be the result usually not of necrosis, but of thinning by stretching. The adjoining parts are more or less involved in the periarteritis, and the nerves and numerous Pacinian bodies (about the aorta) are compressed: this perhaps accounts for the pain.

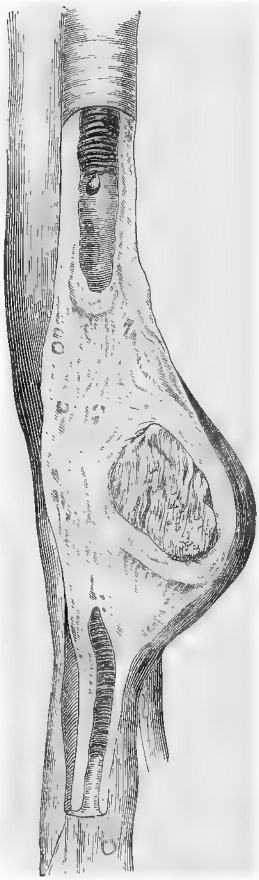
The *contents* of the sac are liquid and clotted blood and layers of fibrin in varying proportions. Almost all sacculated aneurysms show pale tough layers of fibrin adherent to the wall, sometimes in such quantity as almost to obliterate the cavity. This fibrin, the "active clots" of Broca, is arranged in layers, of which the most external, those adjoining the wall, are the oldest; they are opaque, gray, with darker, reddish streakings parallel to the surface. They are evidently formed by slow deposition from the blood, and the darker stains are due to slight clotting of the blood upon their surface or after it has made its way into their interior along lines of cleavage. The soft black clots, Broca's "passive clots," are formed by the rapid coagulation of the blood in bulk, the ordinary clotting, such as occurs when blood is withdrawn from the body. Neither variety has any structural or vital connection with the wall; each simply rests upon it, and is not bound to it by any permeating tissue or blood-vessels of new formation. The few cells that are sometimes found within them are the remains of the leucocytes of the blood. The edges of the

[1] Thoma, *Virch. Arch.*, vol. cxi.

white fibrinous clots are often snugly bound down in places by the extension over them and the adjoining surface of the clot of the endothelium lining the uncovered part of the sac. As the sac increases in size the fibrinous clots become partly detached or broken, and then when additional deposition takes place the new layers are not all parallel to the old ones, but meet and cross them at varying angles that clearly indicate the mode of increase.

The mode of formation of the laminated ("active") clot has been the subject of much discussion, and various theories have been advanced in explanation of it. One of the early theories, that it was not deposited from the blood, but was plastic lymph, an exudate from the wall of the sac, is in hopeless discordance with the observed facts, which clearly indicate that the oldest layers are those that lie nearest to the wall. Another, advanced by Richet[1], and adopted by Holmes[2], is that each layer is the result of the contraction and transformation of a preceding soft dark "passive" clot from which the serum has been gradually expressed, and whose corpuscles have disappeared by molecular degeneration. Another (Broca) is that it is formed by the gradual deposition of fibrin from the blood whipped out in the passage of the latter in its slow and irregular course along the surface; the arrangement in layers is explained by temporary arrests of the process.

Fig. 351.



Popliteal aneurysm cured by formation of a "passive" clot.

Several weighty facts that have come into notice of late years militate strongly against the second theory. Thus, in a case reported by Wagstaffe[3] a popliteal aneurysm which had been cured a few months before death by the use of Esmarch's bandage the sac (Fig. 351) was two inches long and one inch in diameter, and contained a central blood-clot measuring one by half an inch, surrounded by fibrous tissue which appeared to be the thickened wall of the artery and sac and contained blood-vessels. In this case the soft clot had produced no laminæ. A similar case was reported by Reid in the *Lancet*, 1876, ii. p. 184, and in another, cured by the same means, an area of fluctuation, not pulsating, formed a day or two after the treatment, apparently due to the exuded serum of the clot; it gradually disappeared and the cure was permanent. In other cases inflammation or irritation of the inner surface of the sac has been followed by diminution or cessation of pulsation and reduction in size of the aneurysm, apparently by the rapid deposition of fibrinous layers; and in other cases, in which death has followed

[1] Richet, *Dict. de Méd. et de Chir. pratiques*, art. "Anevrysme." [2] *Loc. cit.*
[3] Wagstaffe, *Trans. London Path. Soc.*, vol. xxix. p. 72.

shortly after operative production of such irritation, the irritated parts have been found thickly coated by such layers.

The behavior of the blood under other circumstances also indicates that simple slowing or arrest of the circulation does not lead to the production of such layers upon an unaltered arterial or vessel wall; thus, after an artery has been tied in continuity or in an amputation the portion that lies between the ligature and the nearest proximal branch—a portion in which the blood is almost or quite stagnant—is habitually found uncovered by clot and often shrunk to a diameter much smaller than normal. Furthermore, in an old aneurysm partly occupied by laminated clots the extension of the endothelial layer of the intima over the surface of a portion of the clot appears to prevent subsequent formation at those protected points.

The theory, then, which seems most in harmony with the facts is, that the laminated clot is formed by slow repeated deposition from the blood under the provocation of some mechanical or chemico-vital condition of the surface upon which the deposition takes place.

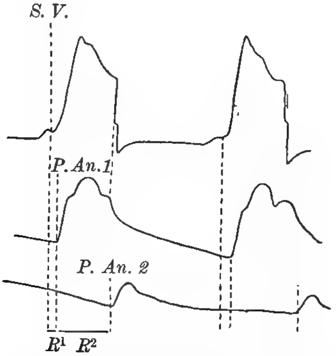
So long as the tough laminated clot is adherent to the wall of the aneurysm, it partially protects it from the distending force of the blood, and thus checks the growth of the aneurysm; but as its connection with the wall is not structural, as it is simply deposited upon it, and not bound fast to it by interlacing tissue, it may become detached in whole or in part by mechanical violence or change in shape, and to that extent cease to be protective.

Of soft, dark (passive) clots much less is known from direct observation: those that are found on the autopsy-table are doubtless formed after death or very shortly before, and of those that are formed during life by accident or treatment we can only infer the changes and relations from what is found at a later period and from what is known of the behavior of such clots elsewhere. We know that when an aneurysm ruptures and allows blood to escape into the adjoining tissues, the blood clots, and probably clots form more or less readily in the secondary pouches that sometimes are found in old aneurysms; but it seems unlikely that large, soft clots form even in sacculated aneurysms unless the circulation in them is almost wholly arrested. When they do so form, the natural shrinkage which they undergo by the escape of their serum must create a space into which the blood will again enter unless the orifice of communication or the artery itself has been plugged, so that only under exceptional circumstances can the formation of such a clot arrest the progress of the affection. In the cases in which cure has followed temporary arrest of the circulation, as by compression or the use of Esmarch's bandage, it is probable that the artery itself has been occluded by the clot and has remained impervious. The cases referred to above of cure by the use of the Esmarch bandage indicate that under such circumstances the expressed serum of the clot is absorbed by the adjoining tissues, the sac shrinks and thickens as the clot grows smaller, and the artery is permanently occluded by the growth of granulations from its wall into the obstructing portion of the clot that has extended into it.

The influence of an aneurysm upon the circulation in the vessels beyond it depends upon a number of variable conditions, such as the

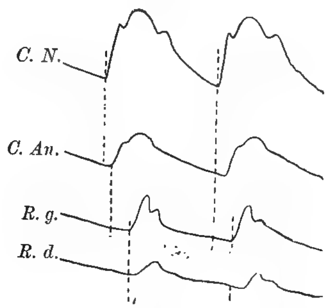
position, size, and shape of the aneurysm (for the arterial circulation) and its pressure upon venous trunks (for the venous and capillary circulation). In considering the effect upon the arterial circulation the aneurysm is to be regarded as an elastic reservoir into which the blood brought by the proximal portion of the artery is temporarily diverted, with the consequent diminution and retardation of the cardiac ven-

FIG. 352.



Half-diagrammatic, showing retardation of pulse in an aneurysm near the heart (*An. 1*) and in one far from the heart (*An. 2*) (Michaux).

FIG. 353.



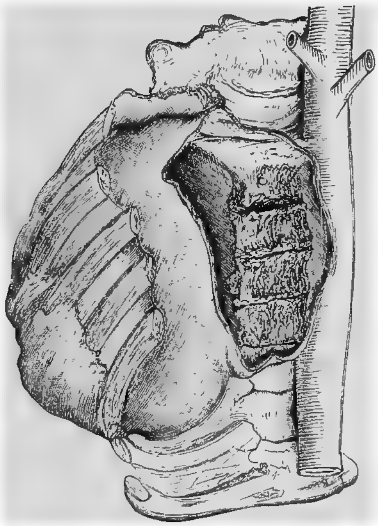
Showing the retardation and reduction of volume of the pulse in the right carotid (*C. An*) and right radial (*R. d*) as compared with that in left carotid (*C. N.*) and left radial (*R. g*), in a case of innominate aneurysm (Michaux).

tricular impulse in the distal portion and branches. The sphygmographic trace on the artery below the aneurysm shows, therefore, a primary elevation that is retarded, less abrupt, and less high than that of the corresponding artery of the other limb, and the dicrotic rise on the descending trace is less marked or absent; in other words, the distal stream is more steady, the variations of intra-arterial pressure and arterial expansion due to the cardiac systole and diastole are slighter than under normal conditions. The physical conditions and effect are similar to those of the common atomizer or force-pump, in which a compressed body of air transforms an intermittent impulse into a constant one and produces a steady stream. The effects upon the venous and capillary circulation are the ordinary ones of obstruction to the venous flow when the aneurysm is so large and so situated as to make pressure upon an important venous trunk.

The tissues and organs adjoining an aneurysm may undergo important changes in consequence of its presence and pressure; those that are movable are pushed back by it as it grows, and those that are or become immovable ultimately undergo molecular absorption, gangrene, or ulceration. Thus, veins are first occluded by pressure, and then obliterated by adhesion of their walls; overlying bones, notably the ribs, sternum, and bodies of the vertebræ in the case of aortic aneurysm, gradually disappear at the points of pressure, evidently by a rarefying osteitis; overlying skin or the wall of an adjoining cavity, such as the œsophagus or the trachea, becomes adherent to the sac, then thinned, and is finally perforated by ulceration or gangrene which involves the sac and leads to a usually fatal hemorrhage.

More remote changes may follow in consequence of the interference with the circulation by pressure on the veins or the plugging of the artery at the aneurysm, or of the detachment of larger or smaller portions of clot, which are then swept out by the blood and lodged as emboli at distant points. Gangrene of a portion of the limb below the sac may be caused by the mechanical interference with the venous return occasioned by the size of the aneurysm or by emboli coming from its interior, especially in the old. Emboli of small size are sometimes found after death under circumstances that indicate that they have done little or no harm; in other cases rough manipulation of an aortic aneurysm has been followed immediately by convulsions and death, and the autopsy has shown the brain, liver, and kidneys studded with emboli in their smaller arteries, evidently detached by the handling. One such case occurred under my observation.

FIG. 354.



Aneurysm of the thoracic aorta, eroding vertebræ and ribs; front of sac removed to show vertebral bodies. (From a preparation in Charing Cross Hospital Museum.)

Finally, subcutaneous rupture of the sac may occur, and if the aneurysm is upon a large artery the blood may escape into the adjoining tissues or cavity (peritoneal, pleural) in quantity sufficient to cause death within a short time or immediately; if, on the other hand, the artery or the rupture is small, the bleeding is soon stopped by the pressure of the parts and the clotting of the escaped blood. There are some facts to indicate that a well-defined wall continuous with that of the aneurysm may form about such escaped blood and constitute a pouch or secondary aneurysm, but it seems probable that such rupture, occurring in the later stages of the evolution of the sac, would be the precursor of other similar ones, and that the patient would seldom survive the accidents long enough to permit the formation of such protective conditions.

Symptoms and Course.—Subjective symptoms of an aneurysm are mainly due to its pressure upon other parts, and consequently seldom appear before it has gained considerable size: then the patient experiences more or less constant pain, dull and aching or neuralgic, a sensation of weight or weakness in an affected limb, or dyspnœa or dysphagia if the affection involves the thoracic aorta; in intracranial aneurysms he is conscious of a persistent murmur or bruit.

The objective signs are those of a well-defined, elastic, fluctuating, usually pulsating tumor, unaccompanied, at least at first, by inflammatory symptoms. It may be at first recognized by chance, or the patient's attention may be called to it by vague sensations or by a feeling as if something had given way or was increasing rapidly and making pressure. If the tumor is so situated that it can be distinctly palpated in its earlier stages, it appears smooth and regular in outline, globular or ovoid, rarely

smaller than a cherry or larger than an orange, in consistency like a not very tense cyst, and capable of reduction in size by broad uniform pressure upon the tumor itself or by compression of the artery above it, with immediate return to its original size when the pressure is removed: when the hand is placed upon it distinct pulsation corresponding to that in the arteries is felt, and if it is grasped between the thumb and finger placed on its sides, the pulsations will be equally well felt and will slightly separate the fingers at each stroke—"expansile pulsation." The finger may at the same time feel a distinct vibrating thrill, but this phenomenon, constant in arterio-venous aneurysm, is rare in the form now under consideration. Auscultation reveals the aneurysmal bruit or murmur, usually soft or blowing, sometimes harsh and rasping. It has been attributed to vibration of the borders of the orifice of the surface occasioned by the current of blood, but seems more probably due to waves created by irregularities of pressure: similar sounds can be produced by pressure with a stethoscope upon an artery, a vein, or even upon a rubber tube through which water is flowing.

Diminution of the force and volume of the pulse in the artery or its branches beyond the aneurysm, when compared with the corresponding vessels of the other side of the body, is generally recognizable by touch; its slight retardation by a fraction of a second can be demonstrated by the sphygmograph.

The tendency of an aneurysm is clearly toward increase in size and ultimate rupture, but the increase takes place with varying rapidity and is occasionally arrested for longer or shorter intervals. Spontaneous cure, in the sense of permanent or very prolonged arrest of growth, reduction in size, and cessation of pulsation and murmur, is sometimes observed; it will be subsequently considered in detail. The rate of growth appears ordinarily to be slowest in fusiform aneurysms, but changing conditions of the sac and its contents may result in marked retardation or long arrest of growth of even a rapidly-growing sacculated one: such conditions are the deposition of fibrinous layers upon the wall, or, apparently, the formation of a large soft clot which occludes the orifice. The effect of fibrinous layers is well shown in cases treated by distal ligation of some of the branches of the artery: the artery remains pervious, blood continues to flow through it and the sac, but the latter shrinks and does not again increase. At the autopsy it is found to be lined throughout by fibrinous clots having a smooth shining surface. The process appears to be—deposition of the layers and shrinking of the sac in consequence of the diminution in the force and volume of the stream; then gradual spread of the endothelium over the surface of the layers, by which their edges are fastened down and their surface is made more like that of the normal intima. Similar circulatory conditions (and consequent results) may be produced spontaneously, as by detachment of a clot and plugging of distal branches.

The increase in size may be uniform, the aneurysm retaining its shape and consistency and simply growing larger, or it may be more marked at some points than at others, and the tumor is then usually softer at such places; the pulsation may change in force from time to time, and the murmur cease or change in character. The subjective symptoms —pain, sense of weight, etc.—increase, and special ones may be added

by implication of special organs, as in thoracic or abdominal aneurysm. Pressure-symptoms increase or are added; the limb or face becomes œdematous or passively congested by venous obstruction; the voice may be altered by pressure upon the recurrent laryngeal nerve; dyspnœa may be caused by pressure upon the lung or trachea or bronchus; severe pain, by the stretching of a nerve or by osteitis set up in the vertebræ, ribs, or sternum. As the skin is approached it becomes permanently discolored, then adherent to the sac, and breaks down by sloughing or ulceration. Growth in other directions may effect a similar change in other hollow organs, such as the trachea, œsophagus, pericardium, pleura, or peritoneum, or rapid growth at one point may lead to rupture of the sac, with escape of blood into the surrounding tissues, and consequent formation of a hæmatoma or "diffuse secondary aneurysm." Such a rupture may, under suitable conditions, be recognized by the rapid formation of a swelling that is usually ill-defined and without pulsation or bruit. If the flow of blood through the sac is not too profuse and continuous, a fairly well-defined wall may form about it, continuous with the primary sac and practically forming part of it; the swelling then becomes more defined and pulsation and bruit may appear in it.

Slight transient inflammation of the sac or adjoining parts, as indicated by tenderness, and perhaps by redness and œdema of the overlying skin, is not infrequent; acute inflammation going on to suppuration is rare and very dangerous. Such acute inflammation has been observed under circumstances that indicated that it was caused by sudden clotting of the blood within the sac, but Broca's statement that such clotting was very likely to lead to such a result has proved to be an exaggeration. The occurrence of this complication is marked by notable local changes and constitutional reaction: the tumor ceases to pulsate, the overlying parts become swollen, red, painful, and throbbing, as in other acute inflammations, and the patient is feverish and may have rigors or even a sharp chill. The subsequent course is that of an abscess, and dangerous hemorrhage may ensue. Exceptionally, the plugging of the orifice and of the artery may be permanent, and the process may end in the cure of the affection. A similar process may be the result of suppuration originating in the adjoining tissues outside the sac.

Inflammation of the aneurysm when it is situated upon the main artery of a limb is very liable to be followed by gangrene of the distal portion, because of the interference with the arterial supply by clotting and with the venous return by pressure.

Rupture of the aneurysm through the skin or into some cavity of the body is an extremely grave accident. The resultant hemorrhage may be profuse and promptly fatal: if small or if arrested by clotting, it is soon repeated, and a fatal termination can only be prevented when it is possible to secure the artery above the aneurysm.

Spontaneous Cure.—Mention has already been made of the fact that sometimes aneurysms spontaneously diminish in size, even to the point of disappearance, lose their pulsation, and are, in fact, permanently cured. As the processes by which this arrest or cure is effected have furnished the principles upon which the treatment of aneurysm has been largely based, they deserve separate consideration. The cure may be effected either by the continuous deposition of laminated clot or by the

sudden clotting of all the blood in the sac, and either of these processes may be the result of a variety of circumstances. Thus, we have seen that the deposit of layers of fibrin upon the wall is apparently the result of slowing of the stream or of change in the character of the inner surface of the sac, and possibly also of change in the character of the blood; consequently, anything which produces these changes may exert a favorable influence upon the progress of the affection, and may even arrest it permanently. In like manner, the sudden clotting of the blood in the sac may be excited by important changes in the wall or by plugging of the orifice of the aneurysm or of the artery above or below the orifice.

The influence of change in the character of the blood is shown by those cases in which arrest of growth has taken place during serious acute diseases. Barwell quotes one of a subclavian aneurysm cured during an attack of enteritis, and one of the femoral during an attack of acute rheumatism, and the many cases of improvement and some of cure by the internal administration of drugs thought to increase the coagulability of the blood, combined with rest and low diet, might be quoted also in illustration, although in all these cases the quieting effect upon the circulation of the enforced confinement to bed must be taken into account.

The slowing of the circulation as a factor may be either general or local. Absolute quiet in bed, combined with a low and unstimulating diet, cardiac sedatives, and sometimes venesection, has long been recognized as a potent aid in the treatment of internal aneurysms not suitable for surgical interference. The influence is most marked in sacculated, pouched aneurysms (as compared with fusiform), and probably the maintenance of the recumbent position has a notable effect upon the circulation within such an aneurysm for physical, mechanical reasons, even when it has little or none upon the general circulation.

Slowing of the circulation within the sac itself must depend upon a variety of conditions, such as the size of the orifice, the shape of the sac, the pressure of clots; and doubtless the blood in every aneurysm varies greatly in its rate of movement and change in different parts of the sac and at different times. There is reason to suppose that portions of clot sometimes become detached from the wall and lodge in the orifice, thereby greatly checking the flow of blood through it, and thus effect a cure, or that a similar condition is produced by the growth of a clot at the edge of the orifice. Probably a complete clot formed within some well-defined pouch may, under favoring conditions, increase rapidly and fill the entire sac. A piece of laminated clot detached from the wall and carried out into the artery by the blood may lodge in the artery a short distance below, usually at a bifurcation, and either reduce the amount of blood that passes through the vessel, and thus slow the circulation in the aneurysm, or obstruct the vessel entirely, either immediately or by its subsequent increase in size, and thus arrest the stream and lead to the formation of a large soft clot that fills the aneurysm and the artery below it.

It has been claimed that a sacculated aneurysm has itself in some cases occluded the artery by pressure upon it above or below the orifice, but the alleged cases are not demonstrative.

Where the inner surface of the sac is smooth and lined with endothe-

lium the tendency to the formation of laminated clot is slight or absent; but where such a protective surface is not present, as in sacs of rapid growth, the deposit is favored; and when rupture takes place the blood that has escaped into the adjoining tissues appears to be prone to clot in bulk, and such a clot may be the starting-point of one that will fill the aneurysm entirely. To a still greater degree an inflamed sac is favorable to the complete clotting of the blood and to the cure of the affection, if the patient does not perish by hemorrhage or if the resulting interference with the venous flow does not lead to gangrenous changes that necessitate amputation. A few cases have been reported in which such inflamed sacs have ruptured externally, with discharge of clots and liquid blood, and the patients have recovered; but the accident is full of danger.

Occasionally aneurysms that have long remained quiescent, apparently cured, begin again to increase in size: such rarely pulsate or have a bruit, and they probably receive their blood by a recurrent flow through the distal portion of the artery.

Diagnosis.—The diagnosis of an aneurysm that is developing in the usual manner, and has not undergone any of the important complicating changes above mentioned, and which is accessible to inspection and palpation, is usually easy. The well-defined outline of the tumor, its consistency, expansile pulsation and murmur, and its position on the course of an artery are all readily recognizable, and in addition we have its steady, rather rapid growth, the absence of the signs of inflammation, the diminution in size when the artery is compressed above it, its sphygmographic trace, and the diminution of pulsation and the change in the sphygmographic trace of the artery below it. On the other hand, aneurysms in the thorax or abdomen or at the root of the neck may be wholly inaccessible to palpation, or so slightly so as not to afford positive diagnostic signs, and those of the limbs may have undergone changes or complications that abolish or mask such signs. Furthermore, other affections may resemble aneurysms quite closely. Many errors of diagnosis, some of them disastrous in their results, have been made, such as mistaking a rapidly-growing aneurysm for an abscess or a shrunken, quiescent one for an enlarged lymphatic gland; but, as Mr. Barwell says, the greater number of these disasters have been due to insufficient caution—to resort to the knife without having made a careful examination; and he calls attention again to the importance of a strict observance of the old rule, which forbids the opening of any swelling in the course of or over a large artery without a previous thorough search for the signs of aneurysm. The same caution should be used in the case of swellings on the front of the chest.

The difficulties in diagnosis arise from the fact that some aneurysms present few of the characteristic signs of the affection, and, on the other hand, that tumors of an entirely different character may present some of them. Of the characteristic signs, pulsation and bruit are those whose presence in other affections or whose absence in aneurysm is most likely to mislead. As we have seen, they are absent when the aneurysm is consolidated or when the artery supplying it is occluded or compressed, and they may be absent or so slight as to be recognized only with great difficulty if the aneurysm is widely ruptured or if the surrounding parts are much inflamed and swollen. The diagnosis must be made by the aid

of the history, and possibly by change in the pulse in the distal branches of the artery. If the condition permits of delay in order to watch the subsequent progress of the case, the diagnosis may become clear, for consolidated aneurysms do not increase in size, while malignant tumors do.

Pulsation is the symptom which is most likely to lead the surgeon to mistake a tumor of another character for an aneurysm. Such pulsation may be due to the vascularity of the tumor itself or may be communicated to it from an underlying artery. Tumors which possess a pulsation of their own are (in addition to other forms of aneurysm than those now under consideration, such as arterio-venous and cirsoid aneurysms) certain very vascular carcinomata and sarcomata, especially certain ones of bone. The diagnosis in such cases must be made by attention to the character of the pulsation, which is more distinctly expansile in aneurysm, to the absence of fluctuation in vascular tumors, and to their slighter loss of bulk when the afferent artery is compressed. In the bone-tumors careful examination may show change in the shape of the bone and the presence of bony outgrowths or plates in the wall of the tumor near its base.

Tumors, solid or liquid, overlying an artery and receiving pulsation from it may be recognized by the absence of expansion and of shrinkage when the artery is compressed, and by the cessation of the pulsation when the tumor is lifted up from the artery. It must be borne in mind that the pulsation communicated to a solid tumor may seem to be expansile when the palpating fingers cannot be pressed down to its equator: as the tumor is lifted at each beat a wider portion is pressed in between the fingers and separates them exactly as expansile pulsation does. A murmur may be present in vascular tumors or when a solid or liquid tumor presses upon an artery.

Prognosis.—This is always serious, although the actual danger to life or limb may vary greatly in different cases and at different periods in the same case. In general terms, the nearer to the heart the greater the danger to life. Except in the comparatively rare cases of spontaneous cure, the progress is steady toward ultimate rupture, and the larger the vessel the more certain is such a rupture to lead to a fatal hemorrhage, and the smaller is the prospect of being able to arrest the progress by treatment.

Treatment.—The treatment of aneurysm may be *medical* or *surgical.* The former term is applied to that method which seeks to effect a cure by rest, diet, and internal medication; the latter includes all other methods in which some external agent is brought to bear upon the aneurysm, its contents, or the artery upon which it is developed.

The *medical treatment* of aneurysm, first systematized by Valsalva and more recently brought into prominence by Mr. Joliffe Tufnell,[1] seeks to promote the processes of spontaneous cure by the deposition of laminated fibrin, by quieting the heart-action, and by increasing the coagulability of the blood. The main agents in this attempt are prolonged absolute rest in the recumbent position, restriction of food and drink almost to the minimum necessary for the support of life, the internal administration of certain drugs, and sometimes venesection. The method has been employed exclusively for internal aneurysms and those in which

[1] Tufnell, *The Successful Treatment of Internal Aneurysms,* 1864.

operative methods were contraindicated. It requires much resolution and fortitude on the part of the patient to continue the treatment for the necessary length of time, seldom less than six weeks.

The details, as given by Barwell, are—absolute confinement to bed and one of the two following systems of diet, known as the "low" and the "dry." The "low" diet consists of bread, 10 ounces; butter, 1 ounce; rice or tapioca pudding, 6 ounces; milk, 1 pint—divided into three or four meals; once or twice a week a little fish or boiled meat may be added if the patient becomes restless under the deprivation. The "dry" diet is as follows: for breakfast and supper, bread, 4 ounces; butter, $\frac{1}{2}$ ounce; milk, 2 ounces; for dinner, meat, 3 ounces; bread, 3 ounces; water or milk, 3 ounces. The return to ordinary diet at the end of treatment must be gradual. Barwell thinks that venesection at the beginning of the treatment, and perhaps repeated during it, would be advantageous; and Holmes says its moderate use "appears both rational and, as far as we can judge from recorded cases, successful."

The drugs used are belladonna, hydrocyanic acid, aconite, and veratrum to reduce the heart-action, and bromide of potassium to control pain and irritation. Acetate of lead and iodide of potassium have also been used, especially the latter, but without demonstrated benefit. Flint[1] reported a case of aneurysm of the abdominal aorta which was apparently cured by the use of the chloride of barium in doses of from one-fifth to two-fifths of a grain three times daily for about five months, after Tufnell's method had failed. The most rapid improvement coincided with the smaller dose.

Surgical Treatment.—The history of the surgical treatment of aneurysm is mainly the story of the invention and application of a great variety of measures designed to diminish the risk to life involved in the effort to accomplish one of two results—the evacuation of the sac and the abolition of its connection with the artery, or the obliteration of its cavity by "active" or "passive" clots. With few exceptions the immediate object of the different operations has been to initiate or promote the processes of spontaneous cure, and the stimulus to the introduction of new methods in such numbers and variety has been found in the risk to life, or the uncertainty of result, or the inapplicability to certain aneurysms of those previously in use. The great advance made in recent years in securing the prompt and easy healing of surgical wounds has practically deprived most of these methods of all but an historical interest; and, curiously enough, the operative method which has most recently received the stamp of approval and has been put forward as the method of choice is practically the one that stands at the other end of the long list—the one employed and described in the second and third century A. D. by Antyllus.

According to Broca,[2] to whose thorough search and exceptional opportunities we are indebted for our knowledge of the early history of the subject, the art of surgery previous to the time of Antyllus acknowledged itself powerless to treat aneurysms. The affection was known to be dangerous, its gravity was attributed to noxious elements in the blood contained in the tumor, and doubtless attempts had been made to relieve

[1] Flint, *Practitioner*, 1879, vol. xxiii. p. 31.
[2] Broca, *Des Anévrysmes*, Paris, 1856.

by evacuating the blood. What the consequences of such attempts were it is easy to imagine, and until some less dangerous remedy could be found it is plain that abstention must have been the rule. Of the writings of Antyllus upon the subject we possess only what has been preserved through quotation by others, especially by Oribasius, who, writing in the fourth century A. D., quoted among others his chapter upon aneurysm. The forty-fifth book of Oribasius, in which this quotation occurs, was long supposed to have been lost, and was only found about 1825 among other Greek manuscripts in the Vatican. After describing two kinds of aneurysm (apparently our spontaneous and arterio-venous), he says: "It is not right to abandon all aneurysms to their fate, as the ancient surgeons taught, but it would be extremely dangerous to operate on all. So we abstain from touching aneurysms of the axilla, groin, and neck, both because of the size of the vessels and of the impossibility or extreme difficulty of ligating them. We also do nothing for very large aneurysms, in whatever part of the body they may be. We operate upon aneurysms of the extremities, the limbs, and the head in the following manner." He then describes the operation by a straight incision along the course of the vessel, the exposure of the aneurysm, the drawing aside of the vein, and the placing of a ligature upon the artery above and below the sac. The latter is then opened by a small incision and "its contents evacuated without danger of hemorrhage."

According to Broca's translation, it would seem that Antyllus dissected the aneurysm entirely free from end to end, but this appears to be not only intrinsically improbable, but also not in harmony with the rest of the description. Whatever the reason may have been—difficulty of execution, secondary hemorrhage, or the general lowering of the intellectual level—we find the operation restricted in the fifth century to aneurysms at the bend of the elbow (with the interesting addition of preliminary double ligation and intermediate division of the brachial artery two or three inches below the axilla—Aetius) and wholly abandoned a few centuries later. With the Renaissance it again appeared in its original form—ligature above and below, incision of the sac—but still restricted to aneurysms at the bend of the elbow: the invention of the tourniquet in 1674 made its execution easier and encouraged surgeons occasionally to extend its application to other aneurysms; but, on the other hand, the discovery of the circulation of the blood checked its use, through the fear of causing gangrene of the limb by cutting off the supply of the blood, and led to a variety of attempts to secure, after incision of the sac, the closing of the opening into the artery without ligating the latter. In the mean time (1710), Anel, a French surgeon living in Rome, operated upon a large aneurysm at the elbow, due to an unskilful venesection, by tying the artery only above and without opening the sac. In the reasons which he gave for thus departing from the usual practice he says he was confident that the blood contained in the sac would flow out through the distal part of the artery, that the sac once emptied would not fill again, that its walls would shrink and the tumor would disappear; "which did not fail to take place as I had anticipated." Although Anel's operation gave rise to an acrimonious discussion and was repeated two or three times with success, it had no lasting effect upon

practice, and was soon forgotten, and until the latter part of the eighteenth century the only direct method of treatment in use appears to have been the old operation of opening the sac and tying the vessels that opened into it. The results were so bad that even this appears to have been but rarely resorted to, most surgeons preferring amputation, at least in the case of popliteal and femoral aneurysms. It is true that direct compression of the tumor had been occasionally employed from the earliest times and had furnished a few notable successes, but there was nothing in its record, no constancy in its action, no underlying principle, to give it any standing as a reasonable mode of treatment. As we now understand it, its few successes were in part in traumatic aneurysms in which the wound in the artery had time and opportunity to heal, and in part, probably, in cases in which an intercurrent or consequent inflammation of the sac produced a cure.

In 1673, Genja had successfully healed a wound of the brachial artery at the elbow by compression of the vessel above, and his example had been followed in several cases, but it was not until 1765 that the plan was applied in the treatment of aneurysm. In that year Guattani, a surgeon at Rome, cured a popliteal aneurysm by prolonged compression of the femoral artery by means of a long pad and a circular bandage. His idea appears to have been merely to diminish the amount of blood coming to the sac, not to interrupt the stream entirely, for he feared gangrene of the limb if the latter should be done. He repeated it in several cases, generally with success, and his example was followed by others; and it seems probable that the method would have been generally accepted had not proximal ligation of the artery at some distance above the sac been introduced shortly afterward. Notwithstanding the immediate success attending the latter, compression was still regarded as a valuable method of treatment, and indeed toward the middle of the nineteenth century, under the impulse given by the Dublin surgeons, it was, as will appear, extensively employed, not only in cases in which the ligature was thought to be exceptionally hazardous, but also in others as the method of choice. Its great advantage was the avoidance of the risk of secondary hemorrhage; its defects were the difficulty of adequately applying it, the pain, the length of time required, and the occasional failures or relapses.

Ligation of the artery on the proximal side at some distance above the sac was first done in June, 1785, by Desault, and in December of the same year by Hunter. Various circumstances combined to make Hunter's part in it prominent: he has been generally credited with its invention, and the method is known as "the Hunterian." It is also claimed that he based it upon a profound knowledge and consideration of facts and principles of which no other surgeon of his time had any conception, and that, although Desault's operation was earlier, it was entitled to no credit, because it was done ignorantly and without appreciation of its importance or of the principles involved. This claim I believe to have no better foundation than ignorance of what Desault (and even Anel seventy-five years earlier) actually knew and planned, and the crediting of Hunter before his operation with knowledge which he obtained at a later period. This is not the place to discuss the matter in detail; the reader who is interested in it is referred to other works.[1] It is sufficient

[1] Cf. Broca, *loc. cit.*, p. 449; Stimson, *N. Y. Med. Journ.*, Nov. 1, 1884.

here to point out that Hunter's declared object[1] was to tie the artery without opening the sac; to place the ligature at a point where the artery was likely to be healthy, thus to diminish the risk of secondary hemorrhage; and finally, if the latter did occur, to be able to place a second ligature upon the artery without having to make a second incision, or, as he says, without "breaking new ground—a thing to be avoided, if possible, in all operations." Not a word is said in the account about collateral branches between the ligature and the aneurysm, or about the sufficiency of diminishing the flow of blood instead of arresting it entirely, upon which so much stress was afterward laid. In short, he was seeking only to make the current method of operating safer, and had no thought of introducing any new principle affecting the coagulation of the blood within the sac.[2]

The success of the new method—for, although its mortality was about one-third, this was a great improvement upon what had preceded—gave a great impetus to the operative treatment of aneurysm, and within a comparatively few years brought under the ligature nearly every large artery in the body: at the same time the associated risk of secondary hemorrhage and the inapplicability of the method, or its extreme danger when applied, to the aneurysms of the largest vessels, as at the groin and root of the neck, led to great activity in devising modifications and substitutes, and out of the results of this activity came a much more extended and accurate knowledge of the mode of cure, especially the deposit of fibrinous layers, and the conditions favoring it. It was soon learned that total arrest of the arterial stream was not necessary, but that its diminution was sufficient; that such diminution might be efficient even if effected interruptedly, instead of permanently or continuously; and that it might be produced by ligature or compression at the distal side of the aneurysm.

The distal ligature for cases in which the proximal ligature was deemed impossible or too hazardous was first suggested, according to tradition, by Brasdor, a French surgeon, as early as 1790, but he never put it in practice, and left no printed record of the suggestion. The operation was first done by Deschamps in 1798 for aneurysm of the upper part of the femoral artery, and a second time shortly afterward by Sir Astley Cooper for aneurysm of the external iliac. Both patients died, and the operation was so completely discredited that Burns said of it in 1812: "There is no point in the treatment of aneurysm which should be more decidedly reprobated than this; it is absurd in theory, and experience proves that it is ruinous in practice." In the face of such opposition and of the reverses, Wardrop, an English surgeon, believed in it and advocated it, and, after many years had passed, in 1825 had an opportunity to put it in practice successfully in a case of carotid aneurysm. He repeated the operation in a similar case, and then went further and tied the third portion of the subclavian in a case of innominate aneurysm where the carotid was occluded. Although no such distinction appears to have been made at the time, it is the custom now to distinguish between the operations in which the arrest of the current past the aneurysm is total and those in which it is partial, and to call the former "Brasdor's opera-

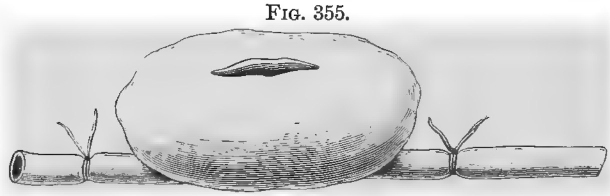
[1] Home, *Trans of Soc. for Improvement of Med. Knowledge*, Lond., 1793.

[2] For the views held by the great majority of American and English surgeons on this subject, see paper by Dr. Billings in the First Volume of this work, p. 86.—THE EDITOR.

tion" and the latter "Wardrop's." That is, in "Brasdor's" the ligature is applied to the main trunk, no branches being given off between the ligature and the sac; in "Wardrop's" such branches are given off, as when the ligature is placed upon the carotid alone or upon the carotid and third portion of the subclavian in the case of innominate aneurysm. To complete the history of the ligature, except for certain modifications in material which will be subsequently mentioned, we may add that antiseptic surgery has made it safe to place the ligature again nearer to the sac, both because it has been found that even a portion of the artery that is not entirely sound can be safely tied, and because the risk of causing rupture of the sac by the suppuration of the wound made to apply the ligature has been almost entirely avoided by primary union of that wound. Moreover, for the same reasons the practice is growing up of extirpating the aneurysm like any other tumor, or of reverting to the "old operation," splitting the sac and tying the artery above and below.

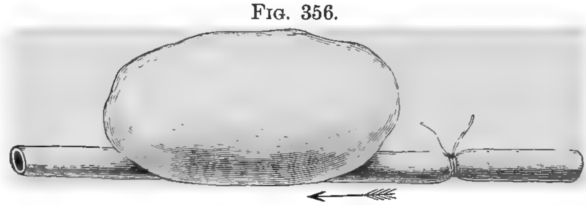
The accompanying figures show diagramatically the various methods of applying the ligature which have been above described:

Fig. 355.



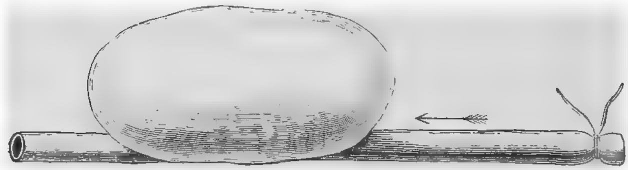
Antyllus: ligature above and below; evacuation of contents.

Fig. 356.



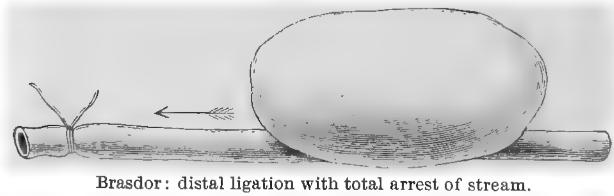
Anel: proximal ligation close to sac.

Fig. 357.



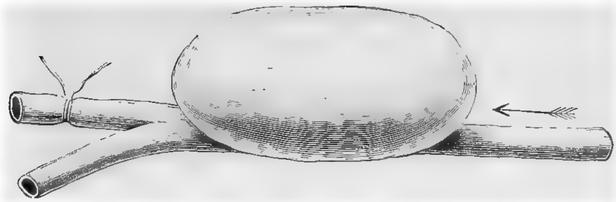
Desault and Hunter: proximal ligation at a distance.

Fig. 358.



Brasdor: distal ligation with total arrest of stream.

FIG. 359.



Wardrop: distal ligation with partial arrest of stream.

Although the risks attending ligation of the artery had been greatly reduced by placing the ligature at a more distant point, they were still serious; according to the most trustworthy estimates, the mortality of the operation (mainly through secondary hemorrhage) was about 20 per cent., and many were the devices subsequently employed to diminish it. Antiseptic surgery and the use of aseptic and absorbable ligatures have done the work so well that most of the others have only an historical interest now, and may be passed with a brief mention.

As modifications of the ligature to produce permanent occlusion of the artery two deserve mention. Dr. Benj. Howard proposed to place a silver wire about the artery tightly enough to occlude it, but without injuring its coats, then to cut both ends short and close the wound over it. It has been used successfully by Mr. Holmes. Dr. Speir constructed an "artery-constrictor," by which the middle and inner coats of the vessel could be divided and curled inward, while the outer was left untorn. It has been used successfully several times.

The attempts to obtain a cure by temporary occlusion of the artery were numerous and varied. Compression of the artery above the aneurysm was coming into use at the time the "Hunterian" ligature was introduced, and it was to it or to some modification of it that the profession turned most frequently and most persistently in the effort to escape secondary hemorrhage. Instruments of various forms, designed to make pressure at one or more points upon the artery without circular constriction of the limb, were devised; bags of shot, weights shaped to fit the limb, rods under elastic pressure, and similar devices in great variety were employed, and sometimes with success. The pressure was sometimes maintained for many hours to produce an immediate cure by means of the soft "passive" clot; in other cases it was employed intermittently, either because the patient could not bear the pain of more prolonged pressure, or designedly with the object of producing the laminated "active" clot.

Digital pressure, maintained for several hours by relays of assistants, was first employed by Dr. Knight of New Haven, Conn., in 1848, and was much used for popliteal and femoral aneurysms, sometimes with the aid of general anæsthesia.

Direct compression of the artery through an incision that exposed it to view was tried in several ways—by acupressure needles; by a wire or thread passed under the vessel, brought up through the skin, and tightened over a cork; by special forceps designed for the purpose which were kept upon the artery for several hours.

Indirect compression of the artery through the aneurysm when the

latter was situated near a joint, by keeping the limb flexed for many days, gave several successes at the knee and groin.

Esmarch's elastic bandage was first used in 1875 by Dr. Walter Reid. About five years later[1] I collected 62 cases in which it had been used—in 85 per cent. successfully, and with 2 deaths. It has since been almost wholly abandoned in favor of the antiseptic ligature, but in any case in which treatment by compression is desired it is probably to be preferred to any other method, for it is safe, fairly efficient, and requires so little time that general anæsthesia can be used. The operative method is simple: thus, in popliteal aneurysm the bandage should be applied tightly to the leg, loosely over the aneurysm, and tightly again above it, and the bandage or tubing should be kept in place for one or two hours; then the artery should be compressed by a tourniquet or the fingers for several hours afterward, the compression being occasionally intermitted to see if pulsation returns in the sac. It has also been used to make distal compression.

As a substitute for the distal ligature, Ferguson in 1852 introduced the method known as "malaxation." In this the aneurysm is forcibly manipulated with the object of detaching a piece of laminated clot from its wall and directing it toward the artery, within which it is hoped it will lodge, probably at the first bifurcation below the aneurysm. It has been employed with success in a few cases. It carries the risk of causing multiple small emboli in the finer branches of the artery; in aneurysms situated upon arteries that distribute blood to the brain the consequences of such an accident are serious.

A final group of methods aimed to effect a cure by acting directly upon the blood contained in the aneurysm, to bring about its slow or rapid coagulation. The simplest of these, the injection of some coagulating solution, usually of a salt of iron, has been occasionally employed, but it has wholly gone out of use, except perhaps as a last resource to gain a few days in thoracic aneurysms that have perforated the chest-wall and are about to rupture externally.

In a few cases wire, horsehair, and catgut have been introduced, sometimes in large quantities; in others needles have been inserted at several points and withdrawn after a few hours. Temporary relief has been obtained by these means in a number of cases, and in one or two a permanent cure appeared to have resulted.

The galvanic current has been used with the object either of making a large soft clot or of starting the formation of a laminated one at various points on the wall. The details of the procedures have varied greatly: one or several insulated needles are attached to each pole and passed into the aneurysm, or the needles are connected with only one pole and a sponge is connected with the other and placed on the skin near by. When the needles are connected with only one pole, it is usually the positive, for the clot formed about it is firmer, less frothy, than that about the negative, but sometimes the current is repeatedly reversed during the operation, and sometimes the negative pole alone has been connected with the needles. Some excellent results have been reported.

Quite recently Macewen has introduced a method based upon the

[1] Stimson, "Treatment of Aneurysm by the Elastic Bandage," *American Journ. of Med. Sci.*, April, 1881.

fact that irritation of the inner surface of the sac promotes the deposit of laminated fibrin at the irritated or inflamed points. The method is termed "needling." He introduces a long stiff needle through the skin, and pushes it through the sac until its point touches the opposite side, and then moves it to and fro so as to scratch the surface over a small area. Then changing its direction, he scratches several other points, and withdraws the needle. It has been employed in a number of cases, and its use has been occasionally followed by improvement in the symptoms.

The present attitude of the profession in respect to the treatment of aneurysm may be summarized as follows:

Antiseptic ligature of the artery at the nearest convenient point above the aneurysm is the method most often to be selected in ordinary, uncomplicated external aneurysms. It is true that statistics, even those quite recently collected,[1] give a mortality following this operation of nearly 20 per cent., but I am convinced that they err by including many earlier cases in which the antiseptic detail was not as accurate as it is to-day. Of 21 cases in New York City of ligation with catgut of large arteries (carotid, subclavian, iliacs, and femoral) for aneurysm, collected by me in 1880, only 1 died, and in that the death was due to rupture of the aneurysm (innominate) into the trachea. Of 12 ligatures applied in the New York Hospital in the years 1888–93 to the carotid, subclavian, and femoral arteries for aneurysm, all were successful, though one of the patients died of general tuberculosis.

Extirpation of the sac with ligation close above and below is doubtless to be preferred in small or medium traumatic aneurysms, such as those following stab or gunshot wounds, and possibly also in spontaneous cases in which the tumor is so large or so inflamed that its interference with the venous flow (added to the occlusion of the artery) will imperil the vitality of the limb.

A return to the old operation of opening the sac and tying the vessel through it was advised by Syme for axillary and gluteal aneurysm, and the advice was repeated as lately as 1876 by Van Buren.[2] A necessary condition for such an undertaking is the possibility of controlling hemorrhage during its performance, and although Syme was able to do that by first inserting his finger through a small incision, making pressure with it at the orifice of communication with the artery, and then enlarging the incision freely, it seems probable that most surgeons would deem such an undertaking too hazardous. Moreover, recent experience has shown that the iliac arteries can be safely reached and tied by laparotomy, so that the necessity for treating gluteal aneurysm by the old method, if at all, no longer exists. The method is still applicable to cases of recurrence after apparent cure by ligature if pulsation cannot be arrested by flexion.

Compression, instrumental, digital, by flexion, or by Esmarch's bandage, continuous or interrupted, may be advisable in a few exceptional cases or when the patient refuses to submit to a cutting operation.

The distal ligature is especially suitable for aneurysm of the innominate, of the first portion of the subclavian, or at the origin of the carotid; and it or distal compression may properly be chosen for some aneurysms of the external iliac.

[1] Delbet, *Revue de Chirurgie*, 1888, p. 807. [2] Van Buren, *Trans. Internat. Cong.*, Phila.

The methods that are designed to act directly upon the blood contained in the sac—coagulating injections, the introduction of foreign bodies, galvano-puncture—are justifiable only where other measures are inapplicable; and probably the same is true of "needling."

In all such cases and in internal aneurysms medical treatment would probably yield as large a measure of success and involve less risk.

2. Dissecting Aneurysm.

This very rare condition has been seen only in the aorta; most of the reported cases have been in females. It has rarely been recognized during life, and is not amenable to surgical treatment. It consists of a partial rupture of the wall of the artery and the passage of the blood between its coats, usually in the substance of a middle coat, but sometimes between the middle and external to a second opening in the lumen of the vessel or one of its branches at a lower point, or to one in the pericardial sac. The primary opening is usually near the origin of the thoracic aorta, but has been seen as low as the bifurcation of the abdominal. Apparently, death usually follows promptly, especially if the blood escapes into the pericardial sac, but in some cases the patient has survived for several years, and the abnormal track followed by the blood has become lined with endothelium. The symptoms are not characteristic: sharp pain in the chest, thought to coincide with the primary rupture, and perhaps a second attack corresponding to the second rupture; faintness, even syncope, probably the consequence of the pain; disturbance of the circulation, possibly a murmur audible near one or the other rupture.

3. Arterio-venous Aneurysm.

When an abnormal direct communication is established between the trunk of an artery and that of a neighboring vein, the condition is termed arterio-venous aneurysm. When the two vessels are in close contact and the blood passes directly from the artery into the vein, the variety is termed *aneurysmal varix*, the prominent feature being a varicose dilatation of the vein and its branches; when, on the other hand, an aneurysmal sac communicating with both vessels is formed by condensation of the adjoining tissues, the variety is termed *varicose aneurysm.* The two forms cannot always be distinguished from each other clinically, and therefore the broader term, arterio-venous aneurysm, including both, is habitually used.

Although, as we have seen, the clinical features which distinguish arterio-venous from the common encysted aneurysm had been recognized as long ago as the second century by Antyllus, the specific anatomical differences remained unknown until comparatively recent times. In 1757, William Hunter, brother of John, published a case, and four years later[1] gave a full description of the affection. Guattani of Rome gave an apparently independent description at about the same time.

In the majority of cases the cause is a traumatism, a simultaneous wounding, rarely a simple contusion, of both artery and vein; in others

[1] Wm. Hunter, *Med. Observations and Inquiries*, 1761.

the communication is established spontaneously, usually by the rupture of an aneurysm into a vein, but in three cases quoted by Holmes the cause appeared to be primitive disease and thinning of the coats of the vessels. In the older days, when venesection was so much practised, the most frequent seat was at the bend of the elbow, and the cause was a wound with a lancet; in modern times the common causes are stab wounds and gunshot wounds; among the rarer ones are fractures, sometimes of the base of the skull, wounding the carotid in the cavernous sinus, and once[1] the communication formed between the femoral artery and vein ten months after an attempt to cure a popliteal aneurysm by prolonged pressure at the point where the communication became established.

In spontaneous arterio-venous aneurysms the aorta is the artery most frequently involved, the communication being most frequently with the pulmonary artery. Thurnam[2] collected 21 such cases, in 12 of which the communication was with the pulmonary vein, in 5 with one of the cavities of the heart (right auricle 2, the others 1 each), and in 4 with one of the venæ cavæ. In 3 the aneurysm was of the abdomimal aorta; in 17, of the ascending aorta, usually in or near one of the sinuses of Valsalva; and 1 of the arch of the aorta, communicating with the left pulmonary artery at the site of the ductus arteriosus. Barwell[3] increased this list to 42, in 3 of which the opening was into the left ventricle. In 19 others in his list the arteries were the carotids (10), external iliac (2), femoral (3), popliteal (2), and posterior tibial (1), and the communication was with the veins of the same name, the internal jugular (6), and the cavernous sinus (1). Of 251 arterio-venous aneurysms of the limbs collected by Delbet,[4] most of them traumatic, 96 were at the fold of the elbow, 34 of the superficial femoral, 26 at the groin, 22 in the popliteal space, 19 of the common carotid and jugular, 11 of the temporal artery, 8 of the subclavian or its branches, 8 in the axilla, 6 in the leg, 5 in the arm, 3 of the external iliac, 3 of the external carotid and external jugular, 2 of the internal carotid, 2 of the common iliac, 2 at the ankle, and 1 of the sciatic. His list apparently is incomplete, for in 1884, I[5] collected, among others, 3 of the internal and 6 of the external carotid.

Most systematic writers describe varieties according to the presence or absence of a sac not formed by dilatation of the vein, and to its relation to the two vessels—that is, whether it lies between them or to one side, or even on the opposite side of the artery. Such differences can rarely, if ever, be recognized clinically, and even when a distinct circumscribed tumor can be recognized it cannot be determined, except by dissection, whether it has been formed in the surrounding tissues or is a limited dilatation of the vein.

The pathological details vary greatly according to the size and the relations to each other of the openings in the two vessels and to their distance from the heart. The principal factor in the production of the changes is the extent to which the intrà-arterial pressure is transferred to and exerted upon the wall of the vein and the aneurysmal sac, and

[1] Pemberton, *Med.-Chir. Trans.*, vol. xliv. p. 189.
[2] Thurnam, *Med.-Chir. Trans.*, vol. xxiii. 1840.
[3] *Loc. cit.*, p. 534.
[4] Delbet, *Anév. art. veineux des Membres*, 1889.
[5] Stimson, *Amer. Journ. Med. Sci.*, April, 1884.

this is determined by the size of the opening and by the resistance offered to the return of the blood through the vein to the heart. The more freely the blood can escape toward the heart, the less is its distending force upon the sac and vein, the less are the changes, and the slower is their increase, and the sooner is that increase arrested and equilibrium established. In other words, the opening into the vein is in most respects an advantageous, conservative condition, retarding or arresting the growth of the affection and making the prognosis much better than that of an ordinary aneurysm.

When the communication is with a large venous trunk, such as the internal jugular, which can readily carry away the excess of blood almost as rapidly as it is poured into it from the artery, the distending action and the consequent changes in the vein are slight; but when the communication is with a smaller vein or one at a greater distance from the heart, especially if the opening in the artery is comparatively large, an immense aneurysmal sac may be formed, or the veins may become greatly dilated and varicose. The distending action is exerted not only upon the vein at and near the point of communication, but also upon its branches, often for a considerable distance on the distal side. The sac, even when not formed by dilatation of the vein, has a smooth surface and contains little or no stratified clot; the walls of the dilated veins are notably thickened in some cases, with, it is said, increase in their muscular coat (Quénu). In a case upon which I operated (common carotid and internal jugular) the dilated deeper veins encountered in the approach to the artery seemed even thinner than usual.

The artery below the point of communication is usually smaller than normal; that is, it is less distended because of the division of the arterial stream, and if it has been entirely divided in the original injury, the lower portion may be occluded at the point of division. Above the point of communication in cases of long standing the artery sometimes becomes enlarged and tortuous and its wall thinned.

The **symptoms**, in the traumatic cases, begin promptly after the receipt of the injury. In the rare cases in which a long interval—ten years in one case, eight and a half years in another—elapsed between the injury and the development of a tumor or of a varicose condition of the veins, it is probable either that the communication was not established at the time of the injury or else that it was very small and subsequently underwent enlargement. In case of an open wound the hemorrhage is likely to be profuse at first, but easily checked by simple measures; occasionally the escaping blood is seen to be mingled arterial and venous. The cutaneous wound heals promptly, and after a few days the patient or the surgeon notices a peculiar thrill in the region of the wound. The subsequent symptoms vary with the conditions: there may be a well-defined pulsating tumor, or the region may be diffusely swollen, or the superficial veins in the neighborhood may be enlarged. The striking characteristic symptoms are the thrill and murmur. The former can be readily detected by placing the palm of the hand upon the part, unless perhaps the lesion is in deeply-seated vessels: it has been compared to the purring of a cat, the hum of a rapidly-revolving wheel, the bubbling about a hot iron plunged into water. The murmur is continuous, with a reinforcement corresponding to the cardiac systole;

it is most intense immediately over the point of communication, and is propagated upward and downward along the vessels, gradually losing its continuous character and becoming purely intermittent as the distance increases. In cases where the opening is into a large vein near the heart, as the internal jugular, and where it is presumably small, the thrill and murmur may be the only objective signs. Expansile pulsation, like that o the common form of aneurysm, may be present when there is a well-defined tumor, and pulsation like that of normal arteries may be felt in some of the enlarged veins. The thrill, murmur, and pulsation may sometimes be arrested by pressure at the point of communication.

Certain subjective symptoms are sometimes present—changes in sensibility of the surface, numbness, cramps, pain along nerves, muscular weakness, and, if the injury is in the neck, possibly occasional dizziness.

Later changes are due to the interference with the circulation and with nutrition in the distal regions. The limb is uniformly swollen, its temperature sometimes elevated, the growth of hair upon it more abundant, and sometimes the limb is increased in length by exaggerated growth of its bones. In other cases the skin may become eczematous or ulcerated.

As has been already stated, the changes after having reached a certain grade usually become stationary, and not infrequently they are sufficiently slight not to interfere seriously with the patient's comfort and well-being. The presence of largely-dilated veins communicating with an artery and near the surface is of course a serious menace to life in case of an accidental wound, but such a contingency is ordinarily too remote to call for active protective measures. In a certain proportion of cases the affection continues to advance, even to the point of rupturing externally. The prognosis in this respect is worse when the affection involves the lower limb.

Treatment.—The plan, and even the principles, of treatment will differ widely in different cases. If the case is one in which the aneurysm has ceased to grow, and in which the circulatory and nutritive changes are not sufficient seriously to interfere with the patient's comfort, it is the part of prudence to abstain from operation and to be content with such palliative measures—bandaging, elastic stocking—as may be indicated.

If the case is a recent traumatic one, and if the thrill and murmur can be checked by pressure at the opening, such pressure, maintained for a considerable length of time, may bring about the permanent closure of the opening. Digital pressure has been the most satisfactory under such circumstances.

In cases in which an attempt at radical cure is indicated by the continued growth of the affection or the urgency of the symptoms, the choice of a method is much more restricted than in an ordinary aneurysm. It must be remembered that we have to deal not with a sac having an irregular rough internal surface more or less covered with laminated clot, and lying outside of the circulatory stream, but with one through which the stream of blood passes steadily, which is largely formed by dilatation of a vein, and which is lined throughout by endothelium and contains no clot. Even in the cases in which a true aneurysmal sac exists between

the artery and vein it has a smooth endothelial surface. A temporary arrest of the circulation, which in an ordinary aneurysm would fill it with a clot, would have no such effect upon a sac formed by a dilated vein, and probably little or none upon the blood in a true sac lying beside such a vein; consequently, all methods of continuous or intermittent compression of the afferent artery are wholly untrustworthy in this affection. In the few successes reported, excluding fresh cases in which direct compression has probably closed the opening, there was probably a distinct sac independent of the dilated veins.

Measures acting directly upon the blood to produce its coagulation, such as galvano-puncture and the injection of coagulating solutions, are not only insufficient, but also dangerous because of the possibility of the detachment of a portion of the clot to be swept away to form a cardiac or a pulmonary embolus.

We can resort only to ligation of the vessels, with or without incision or extirpation of the sac.

In some cases—but, unfortunately, they are the ones that least need treatment—the problem is simple and the solution easy. Such are the cases in which the opening is into a large vein near the heart, and in which there is but comparatively little dilatation or tumor. There we have only to prevent the entrance of the arterial stream into the dilated vein: relieved of the arterial pressure, the vein will return to its normal size, or at least the venous circulation will be carried on without disturbance. Under such circumstances it is only necessary to tie the artery on the proximal side of the opening, or on both sides if a recurrent stream is to be anticipated in case of a proximal ligature alone. The ligature must be applied *close above the opening*, not at a distance from it.

Theoretically, if we consider the cause of the condition alone, the same principles should apply also to arterio-venous aneurysms of the limbs—aneurysms in which there may be a distinct sac and in which the veins are greatly dilated; but proximal ligature of the artery has heretofore yielded very poor results. Van Buren [1] collected, among others, 12 cases in the lower limb: of 7 in which the external iliac or common femoral was tied, gangrene followed in all, and of 5 in which the superficial femoral was tied, gangrene followed in 2. Michaux's collection is even worse—10 successes in 44 cases of single proximal ligature.

Curtis [2] collected 51 cases, of which 23 died, 8 were cured, 2 improved, 18 unimproved, and gangrene occurred in 11. Van Buren's cases, and probably most of the others, belong to the pre-antiseptic era, and the gangrene is probably attributable to interference with the veins, either in the course of the operation or in subsequent suppuration. Otherwise, it must be attributed to some unfavorable influence due to the dilated condition of the veins or to the application of the ligature so far above the aneurysm that the blood brought around the ligature by the collateral circulation entered the artery again above the aneurysm and passed back through it to the heart without having had an opportunity to nourish the limb. It is not easy to see why the former should introduce the element of venous obstruction, which we know to be so important a factor in the production of gangrene after ligature of an artery, and no other explanation has yet been offered.

[1] *Loc. cit.*, 1876.

[2] Curtis, *Am. Journ. Med. Sci.*, Feb., 1891.

The methods proposed are proximal ligature of the artery close to the sac, ligature of the artery above and below (so-called "double ligature"), ligature of artery and vein above and below ("quadruple ligature"), incision of the sac, and extirpation of the sac, the latter two with as many ligatures as may be necessary to control the hemorrhage.

In considering the relative advantages of these methods it is necessary to remind the reader that it is seldom possible to determine clinically whether an aneurysmal pouch—one not formed by a dilated vein—exists in any given case, and that we do not know whether the presence or absence of such a pouch materially affects the result after single or double ligature of the artery. So far as I can judge from what I have seen of such cases, I believe that extirpation of the sac in the great majority of cases cannot be accomplished without double ligature of the artery and of the vein, and the placing of a greater or less number of other ligatures upon the smaller (but also dilated) veins that empty into the dilated portion of the main vein between its two ligatures. Incision of the sac presents the same operative difficulties and the same objections arising from the permanent obstruction of the venous flow. How great those difficulties may be can perhaps be appreciated only by those who have encountered them. I shall long remember one such case which I witnessed: The aneurysm was in the calf of the leg, and after a proximal ligature had been placed upon the artery just below the knee, the surgeon opened the sac in order the more readily to remove it or to tie the vessels that opened into it. It proved to be the vein, the dilatation having a length of nearly a foot and a maximum diameter of more than two inches. In the effort to close the many veins opening into it the incision was lengthened until it reached from the knee to the ankle, and finally, after more than two hours had been spent in the effort, the patient was sent to his bed with compresses packed far down in the lower angle beneath the tendo Achillis to check the free bleeding that came from deep veins of which only the dilated mouths could be seen. In some cases the operation is doubtless much less formidable, as in those in which the dilatation involves only a comparatively short section of the vein, in which the opening in the artery is presumably small; and I am convinced that the operation, if undertaken at all, should be restricted to such cases.

In short, and notwithstanding the unfavorable results heretofore obtained (most of which, I believe, can be attributed to faulty methods), I am convinced that, until sufficient aseptic experience shall have proved the contrary, the only operative measures permissible in cases of arterio-venous aneurysms of the limbs with notable diffuse enlargement are proximal, or double, ligature of the artery close to the opening, and that even this should be undertaken only when the symptoms are urgent and with a keen sense of the operative difficulties likely to be encountered because of the presence of dilated veins in the track of the incision. In aneurysms in accessible situations, not higher than the knee or elbow, in which the sac or dilatation is comparatively small, extirpation of the sac or the quadruple ligature may be permissible; but satisfactory clinical proof of the superiority of that method and of the advantage of removing the dilated portion of the vein from the circulatory tract does not yet exist. Dr. Curtis's two cases are beautiful examples of success obtained in this way, and in thinking that an equally good result might have been obtained

with less difficulty and risk by ligature of the artery alone close above the opening, or above and below it, I appreciate that I am opposing only theoretical considerations to results obtained by actual trial.

4. Cirsoid Aneurysm.

Synonyms.—Arterial varix; Aneurysm by anastomosis; Racemose aneurysm; Pulsating erectile tumor; Cirsoid arterial tumor; Angioma arteriale racemosum.

This affection—which is much more widely known under the name of cirsoid aneurysm than under any of the score of others that have been given to it—is one, nevertheless, whose pathological conditions cannot be brought within the same definition as those of the forms of aneurysm previously considered in this article, and which, indeed, are so far removed from them that several investigators have maintained that it should be included among the neoplasms.

It may be defined as *a dilatation and elongation of an artery and all its branches, large and small*, and, as will appear in studying its pathology, the dilatation may extend through the capillaries to the corresponding venules and veins. Possibly, also, an abnormal direct communication may form between the dilated artery and an adjoining vein, thus creating a condition similar to that of arterio-venous aneurysm. In gross resemblances, although apparently not in its essential characteristics and pathology, the affection in its varying forms approaches, on the one hand, the so-called "serpentine dilatation" of the larger arteries, and, on the other, certain forms of angioma and telangeiectasis.

While references to, or descriptions of, individual cases may be found in the writings of some of the earlier surgeons, the first attempt to describe the affection was made by John Bell in 1801 [1] under the title of "Aneurism from Anastomosis," but of the cases therein described only one appears to have been a cirsoid aneurysm, the others representing various forms of vascular tumors or angiomata. In 1825, Dupuytren,[2] in a paper read before the Académie des Sciences, described a case of dilatation of some of the arterial trunks and branches of the head, and proposed for it the name of "arterial varix," recalling that he had previously proposed the name of "erectile tumor" for the cases of dilatation of the arterial capillaries of the skin and its neighborhood. In 1832, Breschet [3] stated that he had long applied the term "cirsoid aneurysm" (*κιρσός*, varix, and *εἶδος*, like) to the tumors which Dupuytren calls arterial varix. In 1851, Robert [4] read a paper upon the subject, making use of both these names, and paying special attention to the pathology and treatment, but the discussion which followed showed that surgeons still failed to distinguish not only between the various forms of vascular dilatation of spontaneous origin, but also between them and traumatic arterio-venous aneurysm. The paper, however, had the important merit of calling attention to that form of the heterogeneous group observed especially in the scalp, and thus leading to the later and more exact differentiation.

[1] *Principles of Surgery*, vol. i. p. 456.
[2] Quoted by Gosselin, *Arch. gén. de Méd.*, 1807, ii. p. 645.
[3] Breschet, *Mém. de l'Acad. de Méd.*, 1833, vol. iii. p. 101.
[4] Robert, *Bull. de l'Acad. de Méd.* xvi. p. 584.

Robin[1] and Gosselin[2] sought to distinguish a form intermediate between the "erectile tumor" and the "arterial varix" of Dupuytren, marked by the site of the dilatation in the arterioles normally smaller than those involved in arterial varix; for these Robin proposed the name "cirsoid arterial tumor," and Gosselin urged treatment by the injection of a coagulating solution instead of ligature of the afferent arterial trunks. In his description of the minute pathological changes (and they are the earliest I have found) Robin states that they are identical with those found in the dilatation of the larger branches, and that the sole distinction lies in the seat and size of the vessels affected.

Although the term "tumor" had been thus specifically used by Robin in designating the affection, as also less formally for many years previously, Virchow was the first to maintain that its proper nosological place was among the neoplasms, and not among diseases of the arteries, and he suggested the name "angioma arteriale racemosum." To this view was given much additional currency by Heine[3] in an important paper, and it has received further support in more recent years from the practice of the authors of various surgical text-books who have thus classified and treated it, and from special articles formally written from this standpoint. The definition given by the latest writer upon the subject, Wagner,[4] is as follows: "By angioma arteriale racemosum is meant a neoplasm of arterial or arterial-like vessels of markedly progressive character, accompanied by excentric hypertrophy of previously existing arteries of smaller calibre."

As would naturally be expected from the uncertain differentiation of the allied affections in the past, as well as from the difficulties of differential diagnosis, especially from some forms of arterio-venous aneurysm, statistics of the disease heretofore published contain many cases which do not properly belong among them; and those who have subjected statistics to critical examination find themselves compelled to reject a large proportion of the cases. Thus, Wagner accepts only 13 of the 32 cases involving the hand collected by Polaillon and Mink. This throws doubt upon some of the opinions that are current, especially with reference to the etiology and pathogeny, and makes it desirable that a sufficient number of fresh cases, studied and reported with attention to these sources of error, should become available for collation.

In the vast majority of the cases the affection appears upon the head, especially in the distribution of the temporal artery, but also involving the ear and the branches of the occipital. It is also seen in the hand and fingers; and a few cases have been reported in other parts of the body, but the diagnosis is not free from doubt. It is more common in women than in men (of Wagner's 16 cases in the upper extremity, 10 were women, and in 1 the sex was not reported), and it seems to appear more frequently between the ages of fifteen and thirty years; pregnancy, apparently, has an influence in favoring its increase. Many reported cases have been attributed to a traumatism, either an open wound or a contusion, but some of these were undoubtedly cases of

[1] Robin, *Mém. de la Soc. de Biologie*, 1854, vol. v. p. 173. [2] *Loc. cit.*

[3] Heine, *Prager Vierteljahresschrift*, 1869.

[4] Wagner, "Ueber das arterielle Ranken Angiom an der oberen Extremitat," *Beiträge zur klin. Chir.*, 1894, vol. xi. p. 49.

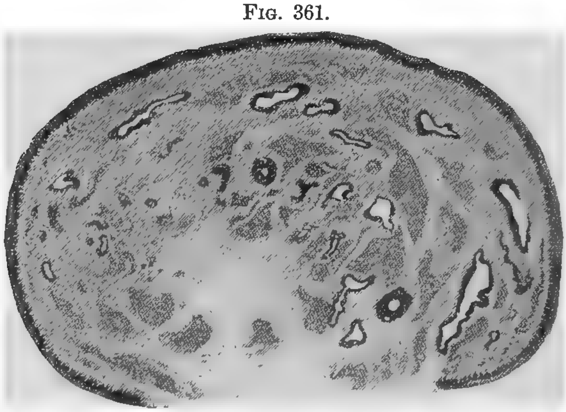
arterio-venous aneurysm; and with regard to the others the possibility of error in the diagnosis or in the attribution of the cause is so great that additional facts are necessary. On the other hand, it appears to be probable that some of the cases observed on the hand and fingers originated in the constant pressure of a tool or implement in habitual use; some of

Fig. 360.

Arterio-venous aneurysm resembling cirsoid aneurysm: *a*, the point of communication (Terrier).

those upon the head have been attributed, much less plausibly, to the irritation of a comb or of a high collar, and König reports one occupying the ear and apparently due to repeated pulling of that member. The alleged origin in a pre-existing nævus appears to be better estab-

Fig. 361.



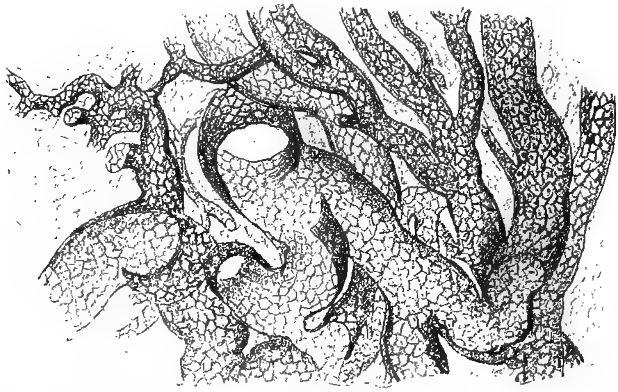
Cross-section of a cirsoid aneurysm of the finger (Quénu).

lished, although doubtless many of the reported cases belong among the pure angeiomata.

The great frequency of the affection upon the head has not been satisfactorily explained; the similar frequency of angeiomata in the same region deserves mention in connection with it.

The pathological changes are striking and characteristic. The tumor, of low elevation and of irregular outline and surface, and, throughout a great part of its extent at least, not adherent to the overlying skin, is

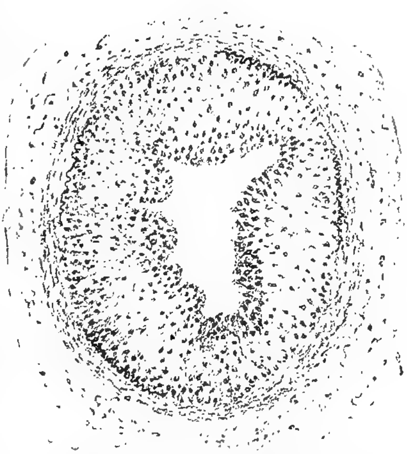
FIG. 362.



Interior of the vessels of a cirsoid aneurysm stained with nitrate of silver.

composed of a congeries of larger vessels having thick and rather rigid walls, so closely packed together and so adherent to one another that even the largest ones do not readily flatten when cut across. Sometimes near the centre of the tumor the vessels are dilated into large sacs. Beyond the periphery of the tumor large sinuous vessels can be seen, some of which can be identified as the normal arteries of the region much enlarged and lengthened, while the others are minute arteries that have undergone dilatation, or enlarged, thickened, and often pulsating veins. The overlying skin is sometimes adherent at points, and even excoriated; the underlying bone is sometimes thinned by the pressure.

FIG. 363.



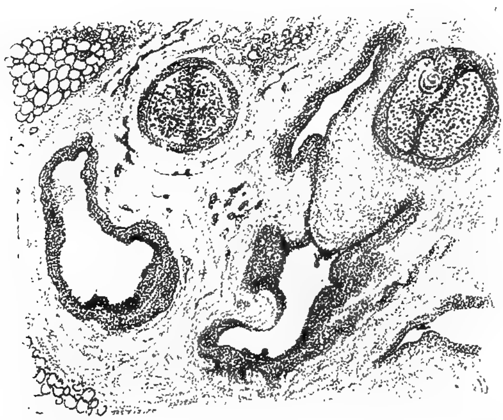
Section of an artery from a cirsoid aneurysm of the finger, showing thickening of the wall (Quénu).

As Robin pointed out, the arteries are not simply dilated, but their walls are thickened, the thickening occupying especially the middle coat, which he describes as redder and softer than usual and containing a certain amount of fatty granules; the outer coat is also thickened and closely adherent to the surrounding cellular tissue. Virchow's description coincides with Robin's, but Heine found marked fatty degeneration, with atrophy of the media. Later examinations have shown thickening of the media to be the rule, at least in the earlier stages, and they make it probable that the thinning sometimes found is a late condition, possibly due to a preceding fatty degeneration of the muscular cells.

Some of the veins show a remarkable thickening of their middle coat, with actual increase in the number of their muscular elements, while others are tense and fibrous and contain but little muscle.

It has not been absolutely demonstrated that abnormal lateral communications form between the arteries and veins, but it is beyond question that the minute branches and capillaries are so generally and largely dilated that the arterial pressure is carried over through them to the veins, and thus becomes probably a principal factor in their dilatation and thickening, since similar changes in the veins are seen in arterio-venous aneurysm. The cause of the arterial dilatation, lengthening, and thickening is not known, but it is certain that the change has a marked tendency to spread along the proximal arteries so long as the central tumor exists, and that this tendency gives place to retrogression, and even to a return to the normal condition after the main body of the aneurysm has been extirpated or otherwise cured. When the affection

Fig. 364.



Hypertrophied veins, from a cirsoid aneurysm of the finger (Quénu).

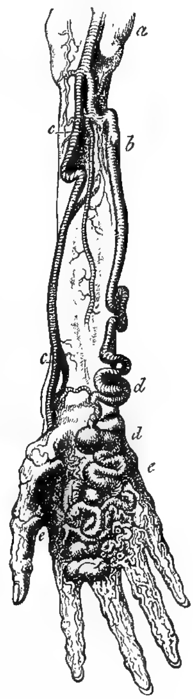
is fully developed, it presents itself as a low, soft tumor of irregular outline and surface and variable extent; the overlying skin may be normal in color, thickness, and attachment to the underlying parts, or it may be thinned, adherent, and vascularized, especially if the affection has originated in a nævus. The skin may appear bluish or reddish-blue by reason of the color of the blood in the dilated vessels beneath; it may also perspire freely, and its epidermic layer may be easily detachable. This latter is especially the case in the hand. In the head the tumor most frequently occupies the hairy scalp and side of the forehead; in the upper extremity, the dorsal or palmar surface of a finger, especially the right index, or the hand.

The tumor is soft, compressible, and pulsating, and the outlines of the vessels that compose it can be seen and felt; on auscultation a soft intermittent murmur is heard. When situated in the head, compression of the carotid on the same side may arrest or diminish the pulsation and murmur; when in the hand, compression of the brachial artery may have the same effect. The arteries leading to the tumor, if sufficiently

near the surface, may be seen and felt to be enlarged and tortuous, and may give the same murmur on auscultation.

The **diagnosis** is ordinarily very easy, but, while a cirsoid aneurysm is not likely to be mistaken for any other affection, an arterio-venous aneurysm or an angeioma may sometimes resemble it so closely as to make the differentiation very difficult. An arterio-venous aneurysm is to be recognized by its more rapid growth, its distinct origin in a traumatism, its continuous and usually harsher murmur and thrill, the absence of dilatation in the afferent arteries, the relative limitation of the change to the veins, and the possibility of arresting the pulsation and murmur by pressure at some point within the limits of the tumor. In angeioma there is rarely a murmur, pulsation is comparatively slight or absent, the individual vessels cannot be distinctly felt, and the vessels beyond the limits of the tumor are not dilated.

FIG. 365.



Cirsoid aneurysm of the hand and fingers (Breschet).

The **course** of the affection is toward increase, sometimes steady, sometimes intermittent, and this increase may be favored by various incidents or conditions, such as puberty and pregnancy. In a very few cases a spontaneous cure has taken place. If the overlying skin becomes adherent and thinned, and finally breaks, serious, even fatal, hemorrhage may result, and of course accidental wounds of the corresponding surface have exceptional gravity because of hemorrhage.

In the various methods of **treatment** that have been employed a cure has been sought in four different ways: (1) By cutting off the supply of blood from the tumor; (2) by extirpating the tumor; (3) by free or multiple incisions through the vessels, and their subsequent obliteration in process of healing; (4) by inducing coagulation of the blood within the dilated vessels.

Ligature of the main artery (temporal or carotid when the aneurysm is situated on the head) has been done in a relatively large number of cases, but with only moderate success: it was strongly recommended by some of the earlier writers, but has now rather fallen into disfavor, because the benefit is usually only temporary, and because of the increasing belief that a permanent and complete cure is to be hoped for only through measures which directly attack the tumor or completely cut off its supply of blood. Ligature of all the vessels that can be seen or felt beyond the margin of the tumor has been occasionally practised, and is clearly to be preferred, notwithstanding its difficulties, to the preceding method.

It has been suggested that the same end, cutting off the blood-supply, might be reached by Barwell's[1] so-called "scarless method" of treating nævus, at least where the aneurysm is of small size. The procedure is as follows: A needle carrying a stout silver wire is introduced just

[1] Barwell, *Lancet*, 1875, i. p. 642.

outside the edge of the tumor and carried close beneath the skin along the margin of the tumor as far as possible, and then brought out; it is re-entered at the point of exit and passed farther along in like manner, and finally brought out at the first point of entrance. The wire, which has thus been made to encircle the tumor, is then tightened by traction upon its ends, and the traction is gradually increased during the following days until the wire comes away. The method is admittedly applicable only to small tumors, and is, I think, clearly inferior to excision.

With the great modern improvements in operative methods and the treatment of wounds extirpation of the tumor has gained so greatly in safety that it may now fairly be termed the method of choice, although when the tumor is very large—that is, when it occupies a large area—the operative difficulties are great, and all the skill of the most experienced surgeon may be needed to keep the hemorrhage within the limits of safety. An incision is made through the skin just beyond the edge of the tumor and carried two-thirds or three-fourths of the distance around it, tying all vessels leading into or coming from the tumor as they are exposed. Then the flap of skin thus circumscribed is dissected back, if possible as far as to its base along the remaining third or fourth of the periphery of the tumor; the vessels thus encountered are also tied, the tumor dissected away from the underlying parts, and the flap of skin replaced. Sometimes the main afferent artery is tied as the first step in the operation, in order to make the control of the bleeding easier. In some cases, where the tumor is situated upon the finger or hand, and where its removal would necessitate the crippling of the member, amputation is to be preferred.

Destruction of the tumor—or, rather, obliteration of its dilated vessels—by incisions into it with the knife or cautery or by caustics is even more exposed to dangerous hemorrhages than extirpation is, and is wholly to be condemned.

The injection of coagulating solutions, such as a salt of iron, into the dilated vessels has been frequently resorted to, and with a considerable measure of success. The associated risk of the detachment of a portion of the clot, with the production of a cardiac or pulmonary embolus, is so great that special measures should be taken to prevent or diminish it, such as prolonged pressure upon the efferent veins. The injection is made by means of a hypodermatic syringe, the needle being introduced directly into the vessels at one or more points. The method is not safe unless the circulation can be controlled.

A somewhat similar end has been sought by attempts to provoke thickening and contraction of the connective tissues surrounding the vessels, either by galvano-puncture or by the interstitial injection of alcohol. Galvano-puncture has proved efficient in the angeiomata, but in real cirsoid aneurysm the results have left much to be desired.

The injection of alcohol, recommended by Thiersch, is made with the aid of the hypodermatic syringe, about one cubic centimetre of 30 to 75 per cent. alcohol being introduced at each point. Care must be taken to throw it into the tissues about the vessels, not into the vessels themselves. Multiple injections are made, and repeated at intervals of a few days. In the case in which Thiersch[1] first employed it the aneurysm

[1] Plessing, *Arch. für klin. Chir.*, vol. xxxiii. p. 251.

was so extensive that he dared not attempt excision. The injections were made about six at a time, at intervals of two days, about two centimetres apart along the margin of the growth, coming, of course, nearer to the centre as the size of the tumor diminished. The improvement was rapid, and persisted even after the induration caused by the injection disappeared. The report was made about three months after the treatment had ended, and at that time there was no indication of recurrence.

SPECIAL ANEURYSMS.

By Percival R. Bolton, M. D.

Popliteal Aneurysm.

The popliteal artery is continuous with the superficial femoral at the opening in the adductor magnus. From this point the vessel descends behind the lower fourth of the femur and the knee-joint to divide into the anterior and posterior tibials at the lower border of the popliteal muscle. The popliteal artery lies in close relation from above downward with the femur, the posterior ligament of the knee, and the popliteus muscle. It is accompanied throughout its course by the corresponding vein, which lies behind and slightly to the outer side, and separates the artery from the internal popliteal nerve.

Lesions.—The aneurysm may occur at any point on the artery, but is most frequently found at the upper or lower part; it may spring from any aspect of the vessel. It may extend upward toward and into Hunter's canal, constituting the so-called femoro-popliteal aneurysm, or downward beneath the muscles of the calf, directly backward or forward, eroding the femur or provoking hydrarthrosis or arthritis of the knee-joint.

In size the aneurysm varies somewhat, and may occupy the entire popliteal space, but rarely exceeds the dimensions of an orange before it demands treatment. Pressure upon the popliteal vein may give rise to œdema, or its occlusion to gangrene of the limb below this point. Pressure upon the internal popliteal nerve may cause paræsthesia or paralysis in the distribution of the nerve.

The sac may rupture externally, among the neighboring tissues, into the knee-joint or the popliteal vein.

In Crisp's group of 551 aneurysms there were 137 of the popliteal.

Etiology.—The popliteal artery seems to be a favorite site of endarteritis, whether consequent on syphilis, gout, rheumatism, nephritis, or alcoholism. Its position renders the artery likely to suffer during movements of the knee from pressure exercised by the neighboring bones and aponeuroses. This combination has therefore usually been invoked to explain the relative frequency of the disease.

Symptoms.—Patients affected with popliteal aneurysm first experience, as a rule, pain of a rheumatic character and referred to the knee. After a longer or shorter interval the tumor is discovered.

The tumor presents the usual features of aneurysm. It possesses an

expansile pulsation, is fluid, reducible upon pressure, presents a thrill and bruit, and ceases to pulsate on compression of the femoral.

With the advent of the tumor, and dependent somewhat upon its size, extension of the knee becomes incomplete. The joint may become affected with hydrops or arthritis, and be further disabled, or the sac may finally burst into the joint. Pressure upon the internal popliteal nerve may possibly cause pain or paralysis in the muscles or skin supplied by it.

Pressure upon the vein may cause œdema of the leg and foot. As a late consequence gangrene of the leg has been occasionally observed. The explanation of its occurrence seems to lie in the relatively poor anastomotic circulation about the knee, both arterial and venous. Add to this fact the probable presence of inelasticity of the smaller vessels, due to endarteritis, and the failure to develop a collateral circulation when sudden obstruction of the main trunk occurs is readily appreciated.

Owing also to the exposed position of the aneurysm, detachment of clots from its interior is quite possible, with consequent multiple embolism of the arteries of the leg and foot.

Prognosis.—Spontaneous cure has been rarely observed. The tendency of the disease is to progress to a fatal issue by rupture or by gangrene.

Treatment.—As a consequence of its comparatively frequent occurrence, its importance, and its accessibility, popliteal aneurysm has been attacked by all known means from amputation to the method of Reid.

Flexion of the knee to arrest the current through the sac has been successfully employed in suitable cases. Barwell[1] has collected 91 cases, with 42 cures. Delbet,[2] however, presents 45 cases, with only 16 cures. An analysis of these cases shows that those cured by flexion have been situated mainly below the line of the knee-joint, with rather thick walls, and where flexion of the knee has caused pulsation to disappear or greatly diminish. The method known as Ernest Hart's method[3] is applied as follows: The limb is surrounded by a flannel bandage, the leg flexed upon the thigh and the thigh upon the abdomen, and retained in this position by suitable apparatus. The patient should lie upon the affected side, with the limb resting upon its external surface, and exposing the femoral region to pressure if this be necessary to reinforce the flexion. The duration of the treatment must vary with the tolerance of the patient and the result produced, and be suspended when pulsation is found to have permanently ceased.

Direct compression of the sac by Reid's method with the Esmarch bandage has in 52 cases collected by Stimson[4] yielded 28 cures, 22 failures, and 2 deaths. Of the failures—in 12, nineteen attempts were made, and indirect compression employed to supplement the direct; in 10, eighteen attempts were made, but without indirect pressure. Of the deaths, 1 was ascribed to shock; in the other gangrene supervened and the patient refused amputation.

The bandage is adjusted, with the patient in the recumbent posture, from the toes upward to the upper third of the thigh, turning the rolls

[1] Barwell, art. "Aneurism," *Internat. Encycl. of Surgery*, Ashhurst, iii. p. 460.
[2] Delbet, "Traitement des Anévrysmes externes," *Revue de Chir.*, vol. viii. p. 872.
[3] *Lancet*, 1859, i. p. 462. [4] L. A. Stimson, *Am. Journ. Med. Sci.*, Apl., 1881.

very lightly over the tumor. Then the limb above the bandage is tightly surrounded by a rubber tube, the bandage removed, and the tube allowed to remain in place about one hour. As the pain attendant on constriction of the limb for this period is intolerable in most instances, the exhibition of an anæsthetic is usually required.

Before the tube is removed a tourniquet is lightly applied to the femoral to prevent a sudden rush of blood into the sac and dislocation of the soft recent clot. After an interval of several hours the pressure is gradually removed and the blood allowed to circulate freely through the limb. If the procedure has been successful, no pulsation will be recognized in the tumor; if, on the other hand, more or less pulsation develop, pressure upon the femoral by the finger or the tourniquet must be continued till consolidation occurs, or after an interval of some days the process may be repeated or the aneurysm subjected to other treatment.

Indirect pressure for the cure of popliteal aneurysm consists in the temporary obstruction of the femoral artery, to excite the formation of clots within the sac. It is accomplished either by means of compression apparatus or by finger pressure.

According to Fischer,[1] in 89 cases treated by indirect compression there were 57 cures and 32 failures. Barwell[2] reports 148 cases, with 68 cures and 80 failures. Of the 80 unsuccessful cases, 57 came to ligature, 19 declined further treatment, 4 required amputation, 6 died. Of the deaths, 2 were due to rupture of the sac (1 into the knee), 1 to gangrene, 2 to thrombosis, 1 not stated. Of the 4 cases amputated, in 2 the operation was done for rupture of sac, and in 2 for gangrene; and of these 4, 2 died from secondary hemorrhage, 1 from spread of gangrene, 1 survived.

Delbet[3] gives 213 cases treated by various forms of compression, with 110 cures and 103 failures.

Digital compression requires the aid of a corps of assistants, who relieve one another in making continuous pressure upon the femoral alternately at the point where it emerges beneath Poupart's ligament and at the apex of Scarpa's triangle, while another assistant, with hand upon the aneurysm, verifies the accuracy and efficiency of the pressure exerted by the others.

The same end may be achieved through compressing the artery by weights moulded in various shapes or shot in bags and weighing from six to twelve pounds. Or, again, a great variety of tourniquets have been used. Of these, Carte's apparatus is the best known. It consists of two portions—one for the groin, the other for the thigh. The former is a padded saddle arranged to fit the pelvis, and supporting on a limb extending over the groin of the affected side a pad whose pressure is controlled by a screw. The thigh-piece is designed to surround the thigh with a large pad posteriorly and a small pad borne on a screw anteriorly for compressing the vessel.

The partial or complete occlusion of the artery results in the gradual or rapid occupation of the sac by clots. While in the former cure seems more certain to ensue, and in the latter relapse is far more common, yet

[1] Fischer, *Prag. Vierteljahresschrift*, 1869, p. 167. [2] Barwell, *loc. cit.*, p. 463.
[3] Delbet, *loc. cit.*, p. 870.

by the gradual method the patient's powers of endurance are taxed to the utmost.

Proximal ligature for popliteal aneurysm has been successfully done in Scarpa's triangle, in the middle of the thigh, in Hunter's canal, and immediately above the sac.

There would seem to be no question as to the advantage of applying the ligature to the superficial femoral rather than to the popliteal above the sac, unless the sac require special treatment. Not only is the femoral less likely to be profoundly diseased than the popliteal, but the operation upon the femoral is easier.

Where anæsthetics are contraindicated, and yet interference is necessary, operation upon the femoral may be done with cocaine, while this agent would not suffice to allay pain during ligation of the popliteal.

Barwell's[1] group of 67 cases operated upon by Hunter's method between 1870 and 1880 shows a mortality of 15.6 per cent.; the mortality for the second half of the decade was 8.57 per cent. The deaths were due to secondary hemorrhage, erysipelas, pyæmia, exhaustion, and rupture of aneurysm formed at the site of operation.

During the next five years 36 operations were done upon the femoral, the vessel being tied in Scarpa's space or Hunter's canal. The mortality was 8.33 per cent.: 91.6 per cent. recovered, some with complications, but 77.7 per cent. made uninterrupted recoveries. The deaths were ascribed to secondary hemorrhage in 1 case; secondary hemorrhage with amputation, 1; gangrene requiring amputation, 1. Of 5 cases, convalescence was interrupted by gangrene in 1; by suppuration of sac in 1; by secondary hemorrhage requiring religature in 1; in another subsequent ligature was applied to the deep femoral, and finally to the external iliac, before cure resulted; and in another relapse occurred after several months, and was finally cured by compression.

Of these 36 cases, 23 had first been submitted to non-operative treatment before resort was had to the ligature.

Extirpation of the aneurysmal tumor itself is but a step in advance of the method of Antyllus, and possesses the decided advantage over the latter, where admissible at all, of securing primary union in the wound. The method where used for popliteal aneurysm is to be preferred in those of small dimensions, or where, owing to its position, the aneurysm creates dangerous obstruction to the venous flow and thus increases the probability of gangrene if the artery is tied.

In general terms, the operation is performed as follows: Apply the tourniquet about the thigh after elevating the limb. A vertical incision is made over the tumor, dividing skin and fascia. The internal popliteal nerve is sought, separated, and retracted by blunt hooks. The vein is next carefully dissected from the sac, tying the numerous small branches as they are divided. The sac is next opened and its contents evacuated. A large probe is passed upward into the popliteal and the vessel tied and divided. The sac is now dissected from its anterior attachments from above downward till the artery below the sac is exposed, tied, divided, and the latter removed. The wound is closed and primary union looked for.

Of 10 excisions of the sac done between 1880 and 1886, and collated

[1] Barwell, *loc. cit.*, p. 466.

by Delbet,[1] all recovered from the operation. In one case death ensued four and a half months later; in another the patient committed suicide after having had consecutive amputations through the ankle and leg done for gangrene; a third developed an area of gangrene on the dorsum of the foot.

M. Schmidt[2] reported a group of 12 cases to the Congress of German surgeons in 1892. Of these, 6 are identical with those reported by Delbet, and 6 are new. Of the additional cases, 5 were successful, and 1 died, of sepsis.

To these we may add the successful cases of Bouffleur[3] and Bax[4] and the cases reported by Küster[5] and Bergmann,[6] both successful, in the discussion of Schmidt's paper. At the same time, Rehn[7] described a case of his in which, during extirpation of a popliteal aneurysm, he had been forced to tie the popliteal vein. Gangrene ensued, but the patient refused amputation and died. This case should not be included in estimating the mortality, nor should the suicide case above referred to.

We thus have a total of 21 cases operated upon, of which 19 may be considered in reckoning the percentage of deaths. Of these 19 cases, 1 died, of sepsis—a mortality of 5.2 per cent. The remaining cases were radically cured.

The operation of Antyllus will find its field of usefulness in cases where inflammation or suppuration of the sac has developed and in cases of recurrence after proximal ligature.

The considerable proportion of cases cured by compression should lead to its use as the first step in the treatment of the disease. Of the two classes of compression, direct and indirect, the former by Reid's method, is to be preferred, not only by reason of the superior facility of its application, but also upon statistical grounds. Digital or instrumental indirect compression has yielded 46 per cent. of cures, while direct compression has resulted successfully in 53.8 per cent. of the cases.

Indirect pressure has resulted in death in 4 per cent. of the cases, or, adding those in which some accident necessitated amputation, in 6.2 per cent.; while, even including all the fatal cases reported by Stimson[8]—one of which is doubtful—direct compression has been attended by but 3.9 per cent. of deaths.

Pressure failing, recourse must be had to operation, and of these proximal ligation by Hunter's method is the procedure of choice. Compared with deligation of the femoral, extirpation has the advantage of a slightly lower death-rate, of effecting radical cures, of escaping the accidents consequent upon ligation and dependent upon retention of the sac—namely, rupture, suppuration, or relapse. Still, with improved technique, sepsis and secondary hemorrhage after ligation should be of rare occurrence, and with their disappearance the mortality should decline.

Finally, the comparative ease of ligation and the possibility of its performance under cocaine will lead to its preference unless the special indications above mentioned exist and require incision or excision of the sac.

[1] Delbet, *loc cit.*, p. 893, et seq.
[2] Schmidt, *Arch. f. klin. Chir.*, 1892, vol. 44, p. 309.
[3] Bouffleur, *Chicago Clin. Review*, 1890–93, i. p. 32.
[4] Bax, *Gaz. Mes. de Picardie*, 1889, lxii. p. 1363.
[5] Küster, *Deutche Gesellschaft f. Chir.*, 1892, p. 97.
[6] Bergmann, *ibid.*
[7] Rehn, *ibid.*
[8] Stimson, *loc. cit.*

Femoral Aneurysm.

The femoral artery, the continuation of the external iliac, enters the thigh beneath the centre of Poupart's ligament, and passes down the anterior and inner aspects of the thigh, to terminate in the popliteal at the opening in the adductor magnus. In the first part of its course the artery is superficial, lying beneath the integuments of Scarpa's triangle. In the middle third of the thigh the femoral is more deeply situated in Hunter's canal, beneath the sartorius muscle. The femoral vein from above downward lies first to the inner side of the artery, then passes behind and overlaps it slightly in the outer side at the beginning of the popliteal. The long saphenous nerve lies upon the anterior surface of the sheath common to artery and vein in the middle third of the thigh.

Lesions.—Aneurysms developed upon the common femoral are classed among the inguinal aneurysms, and are prone to be globular in outline. Aneurysms originating in the superficial femoral are those commonly known as femoral aneurysms. They are more apt to be fusiform, and usually occur at the apex of Scarpa's triangle or just above Hunter's canal. Aneurysms formed upon the deep branch are known as aneurysms of the profunda. Aneurysms of the common or superficial femoral may, by compressing the vein, cause œdema in the limb below. Those of the superficial branch by encroaching upon the long saphenous nerve may excite pain or numbness or tingling.

Etiology.—Femoral aneurysm occurred 66 times in Crisp's group of 551 cases. He says: "Of the 66 cases, ... 21 are marked as femoral or femoro-popliteal; 22 are noticed as being in the groin, 4 as near the groin, and 19 as in the upper third." The greater frequency in the groin as contrasted with the thigh is perhaps to be explained by the superficial position of the vessel here, exposing it to contusion and stretching, which it escapes lower down, and which, judging from the extreme rarity of profunda aneurysms, the deep branch is seldom affected by.

Symptoms.—I. *Of Femoral Aneurysm.*—The symptoms are relatively slight. Pain is usually what induces the patient to examine the thigh and discover the tumor. There may be unusual sensations in the distribution of the long saphenous nerve, or œdema of the limb may be present. The tumor itself is of the general aneurysmal character. The pulse of the dorsalis pedis should show the peculiarities usually found in arteries distal to aneurysms.

II. *Of Profunda Aneurysm.*—Nothing special need be said, save that in the recorded cases it has always been supposed to be connected with the superficial branch. Sphygmographic tracings taken from the dorsalis pedis should show the absence of aneurysm of the superficial branch.

III. *Of the Common Femoral.*—These will be considered in connection with other aneurysms of the groin. (See p. 411.)

Compared with the complications of popliteal aneurysms, those of femoral aneurysm are infrequent. Gangrene is rare, because of the relief given by collateral circulation through the profunda.

Prognosis.—A fatal issue of the disease, whether due to the progress of the aneurysm itself or to the development of complications, is

much rarer than in popliteal aneurysm or aneurysm at the groin, and treatment is more successful.

Treatment.—Compression has yielded more favorable results here than anywhere else. Of Delbet's[1] group of 33 cases so treated, 23 were cured. Of the 33 cases, 10 were treated by the indirect digital method, with 8 cures. Reid's method was employed 7 times, with 3 cures. In the remaining cases mixed methods were used. Indirect pressure by the finger is made upon the common femoral. The sittings may be of greater duration than in the case of most vessels, because of the absence of any great nerve in close relation with the artery.

One of the two failures above noted was ascribed to interruption of treatment by the intolerable pain excited by the pressure. Operative measures have proved much less successful than compression.

Delbet[2] presents 20 cases of ligation, including ligations at a distance from the sac, immediately above it, and above and below, without incision of the tumor. Of the 20 cases, there are 10 cures, 10 failures, though in 1 the final result is not stated. Among the 10 cures are included 2 instances where aneurysm subsequently developed at the site of ligature.

Of the 10 failures, 3 were cured by supplementary operations, ligation of the external iliac in 1, and in the others incision of the sac. There are 3 simple failures and 4 deaths; 1, result not stated. Death is ascribed to sepsis once; to amputation for gangrene twice; to secondary hemorrhage once.

Incision of the sac has been performed 8 times, with 1 death, due to secondary hemorrhage, and 7 cures. In 2 of the successful cases proximal ligation of the femoral had been done previously, and in these cases the operation was performed once for failure and in the other for inflammation of the sac.

Excision of the sac has been performed four times, and each operation was followed by a successful result, notwithstanding that in one instance the vein was tied.

Aneurysms of the Groin.

The external iliac proceeds from the bifurcation of the common iliac opposite the lumbo-sacral articulation, along the inner margin of the psoas muscle to the middle of Poupart's ligament, after passing beneath which it becomes the femoral. The external iliac lies immediately beneath the peritoneum. The accompanying vein lies to its inner side, and the genito-crural nerve upon the anterior surface of its sheath. The common femoral is continuous with the external iliac beneath the middle of Poupart's ligament. It descends through the upper part of Scarpa's triangle for from one to two inches, to divide into its superficial and deep branches. Within this short distance numerous branches are given off.

Lesions.—Aneurysms presenting in the groin may arise from the external iliac or the common femoral artery, or from either of the two main divisions of the latter close to their origin.

Aneurysms situated so high upon the superficial or deep femoral as to prevent their treatment by measures addressed to the affected vessels

[1] Delbet, "Traitement des Anév. ext.," *Revue de Chir.*, 1888–89. [2] *Ibid.*, *loc. cit.*

themselves are included in this group, not solely because they occur in the groin, but also because their management is practically identical with that of aneurysms involving the external iliac or common femoral.

Of these arteries, aneurysms spring most frequently from the common femoral, next from the external iliac, and least often from the superficial and deep femorals. They are usually globular in shape, and tend to enlarge anteriorly when situated in Scarpa's triangle. When confined to the iliac fossa the shape varies greatly. The overlying skin may ulcerate and the tumor rupture externally. It may burst into the iliac fossa or into the peritoneal cavity. Arthritis of the hip has been excited by this form of aneurysm, and ostitis of the pelvis has been observed. Compression of the vein will give rise to œdema of the limb.

Inguinal aneurysm has not infrequently been found to be associated with aneurysms of other arteries. Among Norris's 100 cases, 4 were found to have other aneurysms.

Etiology.—Inguinal aneurysm occurs most commonly in males. Among 100 cases collected by Norris,[1] 95 were in men and but 5 in women, Kirmisson[2] found among 45 cases that 19 occurred between the ages of thirty and forty years, and 30 between twenty and thirty years.

There is no especial difference between the right and left sides in point of frequency. Arteritis, due to syphilis, rheumatism, gout, nephritis, or alcoholism, is the primary factor in the production of the aneurysm here as in other positions. The exposed position of the vessels in question is possibly an important contributory cause. In one or two cases suppuration in the neighboring lymph-nodes, leading to erosion of the artery, appears to have been the cause of the aneurysm; and in several cases compression or ligation of the artery, made to cure an aneurysm at a lower point, has been followed by the formation of an aneurysm at the site of compression or ligature.

Symptoms.—In some cases the first symptom is a sudden sharp pain in the groin, following a blow or hyperextension of the hip or violent muscular effort, which appears to mark the beginning of the affection. After a variable time in such cases, but more commonly without such a history, a small tumor makes its appearance and increases rather rapidly in size.

The point at which the aneurysm first develops is important from a diagnostic standpoint, for after it has reached some size the place of origin becomes difficult of recognition.

The tumor usually possesses the common aneurysmal characteristics—expansile pulsation and bruit. It ceases to pulsate if compression of the afferent artery can be effected, and the sphygmograph shows the aneurysmal tracing.

Gangrene has occasionally been observed as a consequence of inguinal aneurysm, and pressure upon the femoral vein has given rise to œdema of the limb. Inflammation, suppuration, or necrosis of the sac may occur, and produce death by hemorrhage or gangrene.

Finally, erosion of the pelvis or arthritis of the hip may give symptoms.

[1] Norris, *Am. Journ. Med. Sci.*, 1847, xiii. p. 20.
[2] Kirmisson, *Bull. et Mém. de la Soc. de Chir.*, ii., June, 1884, p. 478.

Prognosis.—Spontaneous cure has been very rarely seen in inguinal aneurysms. The tendency is to progress rather rapidly to rupture and death.

Treatment.—Compression by various methods for the cure of inguinal aneurysm has yielded a large percentage of failures. Among 31 cases collected by Delbet,[1] there are 5 cures recorded. In 5 cases flexion resulted in no cures; on the contrary, 2 of the patients so treated died of rupture or inflammation of the sac.

The Esmarch bandage, supplemented by indirect compression applied to the external iliac, has been used in 7 cases, with 2 cures. Of the failures, 3 were simple; 1 rapidly relapsed after apparent cure; and in 1 case rupture of the sac occurred.

Indirect compression has been employed in 16 cases, three times successfully, but with no dangerous consequences in the others.

Although ligation of the common femoral has been condemned as an operation fraught with great risk and its abandonment advised by high authority, the conclusions have been reached upon conditions which no longer exist. Thus, Barwell[2] gives 58 per cent. as the proportion of secondary hemorrhages and 51.6 per cent. as the mortality of deligation of the common femoral. These cases, comprising as they do cases operated upon before the era of asepsis, are misleading. There is no good ground for belief that, with careful asepsis and the use of absorbable ligatures, ligations of several vessels, now rarely practised, may not become successful procedures. Proximal ligature must then be applied to the external iliac.

Delbet's[3] statistics comprise the results of 67 cases in which ligation of the external iliac was performed. Of these 67 cases so treated, 42 were cured, and in 25 cases failure was noted. Among the 25 failures there were 13 deaths, and of these 11 were ascribed to the operation or its consequences and 2 to accidental and disconnected diseases. The mortality, then, is 16.9 per cent. Of the remaining 12 failures, 5 were simple, no change ensuing in the aneurysm; in 5 suppuration of the sac occurred, and resulted in cure; in 1 gangrene necessitated amputation; in 1 secondary hemorrhage required the application of a second ligature and ended in cure.

Kirmisson's[4] group of 40 cases reported between 1874 and 1883 gives a mortality of 12.5 per cent.

Where the point of origin of the aneurysm is uncertain, or its size and position are such as to render ligation of the external iliac by the extraperitoneal method undesirable, or where doubt exists concerning the exact place of application of the ligature, the transperitoneal method may be employed.

This method has several advantages over the extraperitoneal operation. It avoids the extensive stripping up of the subperitoneal tissues, and consequently implies a smaller wound and one which more directly exposes the site of ligature. It allows of choice in the point to be ligated, and that it may be successfully accomplished in the case of the common

[1] Delbet, "Traitement des Anévrysmes externes," *Revue de Chir.*, 1888–89.
[2] Barwell, *Internat. Encycl.*, Ashhurst, vol. iii., art. "Aneurisms."
[3] Delbet, *loc. cit.*
[4] Kirmisson, *Traité de Chir.*, Duplay et Reclus, viii. p. 993.

iliac or either of its branches the cases of Banks,[1] of Stimson,[2] and of Dennis[3] will attest.

Extirpation of the sac has been undertaken twice. The first case was that of Rose,[4] who operated upon an aneurysm recurring two years after ligature of the external iliac. The vein was opened, but a successful result was secured. The other case is that of Bazy,[5] who extirpated a large aneurysm with success after tying numerous large afferent arteries.

Delbet[6] gives 9 operations after the method of Antyllus. Of the 9, 3 died. Of the 3 deaths, 1 occurred where the aneurysm had burst into the hip-joint and simultaneous resection of the joint was done. Gangrene supervened and the limb was amputated at the hip. In another instance the sac, having inflamed as a consequence of ligation of the external iliac, was incised and the patient succumbed to pyæmia. In the third case hemorrhage required the ligation of the external iliac, with fatal result. Delbet very properly excludes the first 2 cases, leaving 7 in which the operation was primary, with 1 death—a mortality of 14.3 per cent.

The small percentage of cures following compression as the treatment of inguinal aneurysm, together with the possibility of dangerous accidents consequent on its use, would seem to place this method among those to be only exceptionally employed. Ligation of the external iliac has yielded 62.6 per cent. of successes and a mortality of 16.8 per cent. (Delbet), 12.5 per cent. (Kirmisson). The method of Antyllus, in the small number of cases reported, is successful in 71.4 per cent., while its mortality is 14.3 per cent.

Ligation of the external iliac continues to be the operation of choice, while incision or excision of the sac may properly be confined to relapses or failures after ligation of the external iliac or compression.

Abdominal Aneurysm.

The abdominal aorta pierces the diaphragm opposite the last dorsal vertebra and enters the abdomen. It descends upon the anterior surface of the lumbar spine and bifurcates upon the body of the fourth lumbar vertebra a little to the left of the middle line. The abdominal aorta gives off many and large branches, but those more commonly affected by aneurysm are the cœliac axis, rising from the anterior surface of the aorta at the margin of the diaphragm, and the superior and inferior mesenteries, arising from below the level.

The common iliac arteries are formed at the division of the aorta into its terminal branches upon the body of the fourth lumbar vertebra, and pass obliquely downward and outward from this point to the level of the lumbo-sacral articulation, where they divide, forming the external and internal iliac arteries. The common iliacs lie immediately behind the peritoneum, the ureters and sympathetic nerves only separating them from this membrane.

The corresponding vein lies to the right of each artery, but both the

[1] Banks, *Brit. Med. Journ.*, 1892, ii. 1163.
[2] Stimson, *N. Y. Med. Journ.*, August 10, 1889.
[3] Dennis, *Med. News*, Phil., 1886, lxix. p. 565.
[4] Rose, *Lancet*, Dec. 22, 1883.
[5] Bazy, *Bull. et Mém. de la Soc. de Chir.*, Jan. 7, 1891.
[6] Delbet, *loc. cit.*

right and left common iliac veins pass behind the right common iliac artery before uniting to form the inferior vena cava, to the outer side of this vessel.

The external iliac arteries skirt the brim of the pelvis along the inner sides of the psoas muscles from the level of the lumbo-sacral articulation to Poupart's ligament, where they enter the thighs. The accompanying vein lies to the inner side of the artery.

The internal iliac artery arises on each side at the bifurcation of the common iliac, and descends to the upper part of the great sacro-sciatic foramen, where it divides into its anterior and posterior branches. The ureter passes in front of, and the internal iliac vein behind, the artery. The branches of the anterior division mainly supply the pelvic viscera, while those of the posterior division are distributed to extrapelvic structures.

Lesions.—Aneurysms occurring within the abdominal cavity arise in most cases from the aorta or the iliac arteries, and more rarely from the branches of these vessels.

Of 157 cases of aneurysm of the abdominal aorta collected by Sibson, 131 were seated close to the cœliac axis and 26 arose below this point.

Aneurysm of the abdominal aorta is usually sacculated, and springs from the anterior or posterior surface of the aorta with about the same frequency. Those aneurysms given off from the posterior wall of the aorta may erode the bodies of the vertebræ or compress the lumbar nerves, or even the ureter, giving rise to renal colic. Those aneurysms arising from the anterior surface of the aorta by compressing the neighboring viscera or their ducts or interfering with their innervation cause symptoms referable to disturbance of the function of the affected organs.

The common iliac artery is but rarely the site of aneurysm, most of the aneurysms of the iliac fossa occurring in connection with the external iliac, while aneurysms of the internal iliac are but seldom seen.

Aneurysms of the iliac fossa are occasionally of considerable size and develop with some rapidity, and that irrespective of their point of origin, but dependent apparently upon the slight resistance offered by the peritoneum.

Gangrene of either extremity may possibly result from clots separating from an aortic aneurysm and causing embolism of the arteries of the limb, and has been observed also as a consequence of iliac aneurysm.

Abdominal aneurysm may burst into the peritoneum or behind this membrane, forming a diffuse aneurysm which later ruptures into the peritoneal cavity, or the sac may rupture into the mesentery, or in the case of aortic aneurysms situated high up rupture into the pleural cavity has occurred.

Etiology.—Abdominal aneurysm occurs oftenest after the age of thirty years, and oftener in males than in females. Endarteritis, produced by any of its usual causes, is probably always the antecedent of aneurysm here as in other situations.

Symptoms.—The disturbance of the function of the abdominal organs consequent upon the development of an aneurysm within the cavity will depend upon the position of the aneurysm. Those aneurysms arising from the upper part of the aorta may possibly give rise to

the symptoms of dyspepsia or to jaundice; they are almost always accompanied by pain, which is explained by irritation of the branches of the solar plexus if the aneurysm spring from the anterior surface of the aorta, or by erosion of the spinal bodies if the aneurysm spring from the posterior surface.

Situated lower down upon the aorta or one of the iliac arteries, the aneurysm gives rise to groups of symptoms dependent upon the organs encroached upon, but it is only when the iliac fossa comes to be occupied by the aneurysm that œdema of the corresponding extremity or symptoms of palsy are developed.

The tumor formed by the aneurysm is usually readily recognized, and possesses no uncommon features other than those due to its position within the abdomen. Several conditions, however, must be kept in mind in determining the nature of an abdominal tumor suspected of being an aneurysm. In many persons whose abdominal walls are thin the aorta may readily be seen pulsating, and not infrequently in such cases, on compressing the vessel with the stethoscope, a distinct bruit is audible, but this is never the harsh aneurysmal rasp, nor is a tumor present.

Solid or cystic tumors of moderate size overlying the aorta, and indeed fecal masses, sometimes convey the pulsations of the aorta and simulate aneurysms; but a purge entirely removes the impacted fæces, and examination of the abdomen, with the patient upon his hands and knees, will serve in most cases to decide between aneurysmal and other tumors.

Much has been said in reference to the distinction between pulsating sarcomata of the pelvic bones and aneurysms, and while, in many cases, the differentiation is attended with difficulty, in most instances the presence or absence of the aneurysmal pulse in the corresponding dorsalis pedis will decide the diagnosis.

The point of origin of the aneurysm is not always easy to recognize; but in addition to the facts furnished by the history of the patient it may be said that aneurysms above the level of the umbilicus arise from the aorta or one of its branches, while those below this level may, rarely, be connected with the aorta, but probably spring from one of the iliac arteries.

Prognosis.—Occasionally spontaneous cure has been found, at autopsies made upon persons who had died of other diseases, to have occurred in aneurysms whose existence was not suspected during life. Recovery has followed treatment, but the tendency of the disease is to progress to a fatal issue by rupture of the sac in one or other of the directions above indicated.

Treatment.—The method of Valsalva has yielded a few successful results, and, unless special conditions exist which do not admit of delay, may be used as the first step in the treatment, especially of aneurysms above the umbilicus. In those situated high in the abdomen this method until recently constituted almost the only eligible plan of treatment.

The rest should be absolute, and the heart-action reduced to a minimum by restriction of diet, administration of iodide of potassium or other sedative drug, and by venesection if the patient be at all plethoric.

This plan is tedious, sometimes occupying weeks or months, and often fails to cure the aneurysm or even stay its growth, although symptoms are frequently ameliorated.

Distal pressure has not yet been successful.

Proximal compression was first successfully practised by Murray,[1] though originally suggested by Holmes,[2] and has now been employed in a considerable number of cases,[3] some of them being cured; but in a few cases disastrous results have occurred, due to injury of the intestine.

Pressure is made by some form of abdominal tourniquet, and of these the instruments of Lister and of Pancoast are the best.

The bowels are emptied by cathartics, and the compressor applied over the artery, with the abdominal wall relaxed by flexion of the thighs, and screwed down till pulsation ceases in the aneurysm, or at least in the femorals.

The pain incident to compression for any length of time makes anæsthesia by some means necessary, but to avoid vomiting the anæsthesia should not be profound. The lower extremities, entirely without circulation, require warm covering. The suggestion that the intestines be gently kneaded from beneath the pad as the latter is screwed down seems plausible, but is really impracticable.

In Murray's case pressure was maintained for ten and a half hours without interruption, but in other cases solidification has been produced in a much shorter time. The patient's condition during this time must be carefully observed, and any failure of heart-action or respiration counteracted or the treatment suspended.

If success is to be achieved, diminution of the tumor and increased density of its walls will be recognized; but even if such do not occur at the end of a reasonable period or the patient's general condition interrupts the treatment, a second attempt may prove rapidly curative,[4] or slow clot-formation may go on within the sac as the consequence of changes effected by the temporary interruption of the current through the sac.

While the successful cases of abdominal aneurysm treated by this method have been but few, this number includes instances not only of aortic but also of iliac aneurysm.

Macewen[5] has applied his needling method to at least one case of aneurysm situated high in the abdomen and unsuitable for proximal compression. The symptoms were markedly relieved. This method, however, is applicable only in those cases in which the aneurysm lies in immediate contact with the abdominal wall—a fact demonstrated by Macewen in the case reported, through inflation of the stomach.

Ligature of the aorta has been done 11 times, and each operation has resulted fatally. In 9 cases the ligature was applied for aneurysm, and in 2 cases for wound of the aorta and of the femoral respectively. In 1 case, that of Monteiro,[6] the patient survived the operation, done for a diffused inguinal aneurysm, and finally died, exhausted by repeated

[1] Murray, *Med.-Chir. Trans.*, xlvii. p. 187.

[2] Holmes, *Syst. Surgery*, 1st ed.

[3] Of 9 cases so treated, 4 were cured, 1 recovered uncured, and 4 died, all of peritonitis.

[4] Sutherland, *Brit. Med. Journ.*, Oct. 5, 1867.

[5] Macewen, *ibid.*, 1890, ii. pp. 1107–1164.

[6] Monteiro, *Lancet*, 1842, i. p. 334.

hemorrhages from the neighborhood of the ligature. The operation was extraperitoneal. The recently reported case of Milton,[1] in which the aorta was ligatured by the transperitoneal method, resulted in death at the end of twenty-four hours.

Notwithstanding the gloomy outlook afforded by examination of the eleven cases so far reported, there seems to be some ground for belief that ligation of the aorta, performed upon a patient not yet exhausted by aneurysmal disease, or as a last resort after rupture of the aneurysm has occurred, might be successful. That a collateral circulation sufficient to carry on nutrition of the lower extremities can develop the case of Monteiro will attest. But without further facts the question of the justifiability of ligating the aorta must remain *sub judice.*

For iliac aneurysm ligation of either the common iliac or of its branches may be undertaken with considerable confidence of success; and of the two methods, extra- or transperitoneal, the latter is to be preferred in all but exceptional cases.

The dangers of opening the peritoneum may now fairly be said to be no greater than those attendant upon the infliction of the extensive wound necessary to reach the common iliac or the upper part of the external iliac by the extraperitoneal operation; indeed, several cases of peritonitis have developed after ligation by the latter method where the peritoneum was said not to have been wounded.

Stimson,[2] Banks,[3] and Dennis[4] have each reported instances in which the main iliac and each of its branches have been tied by the transperitoneal method with ease and success.

Aneurysm of the Buttock.

The gluteal artery, the continuation of the posterior division of the internal iliac, emerges from the pelvis through the upper part of the great sacro-sciatic foramen, and almost immediately divides into superficial and deep branches.

The former passes outward in the interval between the gluteus maximus and medius, while the latter runs between the medius and minimus.

The sciatic artery, derived from the anterior division of the internal iliac, escapes from the pelvis through the lower part of the great sacro-sciatic foramen, along with the sciatic nerves, and, passing downward for a short distance between the great trochanter and the tuber ischii, beneath the gluteus maximus, is distributed to the structures of the region.

Lesions.—Aneurysm of the buttock may arise from either the gluteal or sciatic artery.

The sac ordinarily does not reach very considerable proportions before rupture occurs—an accident to which the position of the aneurysm renders it peculiarly liable. Many, if not most, of the recorded cases of aneurysm of the buttock are instances of traumatic and not of spontaneous aneurysm.

In rare cases the sac has reached the size of a child's head or larger

[1] Milton, *Lancet*, 1891, i. p. 85. [2] Stimson, *N. Y. Med. Journ.*, Aug. 10, 1889.
[3] Banks, *Brit. Med. Journ.*, 1892, ii. p. 1163.
[4] Dennis, *Med. News*, 1886, lxix. p. 565.

before diffusion occurred, and in some cases the aneurysmal dilatation of the artery has involved its intrapelvic portion to a variable extent. The tumor, by compressing the branches of the sacral plexus, gives rise to severe pain in the distribution of the nerves or even palsy. The function of the hip may be impaired or the pelvic bones eroded.

Rupture may occur through the skin or into the neighboring structures, and when the latter happens the blood may be very widely diffused.

Etiology.—Of 40 cases of aneurysm of the buttock collected by Barwell,[1] 12 were spontaneous and 28 traumatic, and of the latter group 16 were due to wounds, 10 to contusions, and 2 complicated sacro-iliac disease.

In the cases occurring independently of traumatism endarteritis probably plays its usual rôle.

Symptoms.—Pain, besides the tumor, is the most important of the symptoms growing out of the development of aneurysm of the gluteal region. The pain is by no means confined to the buttock, but depends upon the distribution of the branches of the sacral plexus that are compressed. Thus, pain may be referred to the dorsum of the ilium, to the perineum, to the back of the thigh, leg, or foot. In character the pain is often rheumatic, and has been mistaken at times for that accompanying sciatica.

The aneurysmal tumor in many cases offers no difficulty in its recognition: fluctuation, pulsation, thrill, and bruit are present and well marked; but in other instances aneurysm may readily be confounded with abscess or sarcoma.

An abscess of the buttock, if cold, is usually associated with demonstrable caries of the bones of the spine or pelvis, and occurs in most cases at an earlier period of life than does aneurysm, while if acute and due to an infected wound or inflammation of the bursa overlying the tuberosity, the existence of constitutional symptoms should lead to suspicion of the nature of the disease, and the introduction of an exploring needle should clear up the diagnosis.

The distinction between aneurysms and malignant tumors of bone has already been referred to (see p. 383); but rectal exploration is of great value, not only in determining the diagnostic features of tumors of the buttock, but also in deciding the treatment to be employed in aneurysms of this region.

Prognosis.—Spontaneous cure, especially of the traumatic aneurysms of the buttock, has occurred; but the tendency of the disease is to progress to rupture and death, and the exposed position of the aneurysm may at any time lead to rupture under the most disadvantageous circumstances.

Treatment.—Treatment of the variety of aneurysm under consideration by Valsalva's method, as might be premised, has little to recommend it.

Compression methods, from the inaccessibility of the afferent vessels and the numerous efferent vessels, are hardly practicable.

In one case,[2] at least, Macewen's needling operation was employed with success.

[1] Barwell, *Encyl. of Surg.*, iii. p. 476.
[2] Carmichael, *Brit. Med. Journ.*, 1893, i. p. 117.

Distinctively operative measures vary in their nature as the aneurysm is of spontaneous or traumatic origin.

In the case of spontaneous aneurysms, too, according as the dilatation occurs only without the pelvis or also involves the intrapelvic portions of the vessel, treatment must differ.

For spontaneous aneurysms of moderate size and wholly confined to the buttock, or, if diffusion has occurred, either proximal ligation close to the sac or incision or excision of the sac, may be done and success looked for.

For aneurysms of considerable size, and especially if extending within the pelvis, proximal ligation of the internal or common iliac must be resorted to, and, owing to the uncertainty as to the extent to which the intrapelvic vessels may be involved, they may be judiciously examined through the posterior peritoneum, and then the proper vessels tied[1] through a small incision in this structure, rather than submit the patient to the risks of a manual examination of the rectum, supplemented by the danger inseparably connected with ligation of any of the iliacs, except the external, through the enormous wound made by the extraperitoneal method.

For traumatic aneurysms, in view of the limited extent to which the arterial wall is damaged, the old operation would seem to be the method of election; at any rate, the necessity of performing ligation of either of the iliacs for this condition will be found very infrequent.

Hemorrhage during incision or excision of the sac may be controlled by compression of the aorta or common iliac through the abdominal wall, or by means of the hand or Davy's rod introduced into the rectum, or by a finger passed through a small incision in the sac and pressed against the orifice of communication with the afferent artery.

Brachial Aneurysm.

The brachial artery is continuous with the axillary at the lower border of the tendon of the teres major, whence it passes down the inner and anterior aspect of the arm to divide immediately below the bend of the elbow into the radial and ulnar arteries. The brachial is superficial throughout its course.

The median nerve crosses in front of the artery from without inward. The ulnar and internal cutaneous nerves lie to its inner side. It is accompanied generally by two companion veins.

Lesions.—Except at the bend of the elbow, aneurysms of the brachial are of great rarity, and here the aneurysm is usually traumatic.

Crisp includes among his 551 cases but a single instance of spontaneous aneurysm of the brachial.

Etiology.—At the bend of the elbow aneurysm has usually been the result of injury, and particularly of a wound of the artery during phlebotomy.

Symptoms.—Owing to the proximity of the median nerve, pain referred to the distribution of this nerve is commonly present, but in consequence of the rich venous supply œdema seldom develops. The aneurysm itself possesses no unusual features. If it reach some size,

[1] Dennis, *Med. News*, 1886, lxix. p. 565.

the movements of the neighboring joint will be found to be restricted.

Treatment.—Compression, either direct by the Esmarch bandage or indirect by digital pressure upon the brachial, has been successful. Its disadvantages seem to lie in the great pain attendant on its practice and the danger of producing paralysis.

Proximal ligation has been almost uniformly curative. Barwell[1] has collected 16 cases, all successful, with 1 instance of easily-controlled secondary hemorrhage. Delbet[2] reports 5 instances of incision of the sac, with 4 cures, the fifth case being lost sight of. He also reports 1 case cured by excision of the sac. To this we may add the successful case of Cellier.[3] This procedure should be carried out when pain or paralysis is a prominent feature.

Axillary Aneurysms.

The axillary artery is continuous with the subclavian at the lower border of the first rib, where it is deeply situated, and becomes the brachial at the lower border of the tendon of the teres major, where it is covered only by the skin and fasciæ. In the first part of its course the artery lies below the brachial plexus, but in the second and third portions the vessel is embraced to a greater or less extent by the cords and branches of the plexus. The vein lies to the inner side of the artery throughout its course. Each portion of the vessel gives off several branches.

Among 551 cases of aneurysm, Crisp found 18 connected with the axillary artery.

Lesions.—The aneurysm may arise from any part of the axillary artery, but more commonly originates in the first or third part than in the second.

In size and shape the tumor varies considerably, being moulded somewhat by surrounding parts. It may be confined to the axilla or it may extend above the clavicle. The shoulder may be elevated and the arm abducted by the tumor. The ribs or clavicle may be eroded and the thorax invaded.

The brachial plexus is compressed, with consequent pain or paralysis in the corresponding extremity. Pressure upon the vein gives rise to œdema.

If rupture of the sac occurs, its contents may escape into the cellular tissue of the axilla, and finally externally by ulceration of the skin, or into the thorax.

Etiology.—To the ordinary causes of endarteritis, gout, syphilis, rheumatism, and alcoholic poisoning there is generally added, in the production of axillary aneurysm, some form of traumatism, and of these attempts to reduce luxations at the shoulder-joint are among the most important.

Symptoms.—Owing to the intimate relation of the sac to the brachial plexus pain referred to the extremity is commonly the chief com-

[1] Barwell, *Internat. Encyclo. of Surgery*, Ashhurst, vol. iii. art. "Aneurysms."
[2] Delbet, "Traitement des Anévrysmes externes," *Revue de Chir.*, 1888–89.
[3] Cellier, *Bull. méd. de Paris*, 1889, iii. p. 757.

plaint made by the patient. In addition, œdema is often a conspicuous effect of the tumor's presence.

As the aneurysm increases in size it may elevate the shoulder, and even present in the subclavian triangle, or the anterior wall or base of the axilla may be encroached upon. The characteristic symptoms of aneurysm will usually be present.

Axillary aneurysms have most frequently been confounded with suppurating adenitides of the axilla, and more rarely with pulsating tumors of the neighboring structures.

Prognosis.—Spontaneous cure has been rarely seen. The tendency of the disease is to progress steadily to a fatal issue by rupture either into the axillary space or the thorax, or externally. Exceptionally the disease may become stationary.

Treatment.—Where other means are inapplicable recourse may be had to medical treatment by decubitus, restricted diet, and iodide of potassium, with or without bleeding.

In a few selected cases of aneurysm of the third part of the artery, without elevation of the shoulder, indirect compression of the subclavian has proved successful, but the process is difficult of application and very painful, and may be succeeded by paralysis of the extremity.

Proximal ligation by the method of Anel is the method of choice. The ligature has been applied to the axillary artery above the sac, but most often, and preferably, to the third portion of the subclavian. The operation presents some difficulty when the shoulder is elevated by the aneurysm, and ready access to the artery prevented by the presence of the clavicle in front of it. Under these circumstances division of this bone by the saw or osteotome and its displacement downward would facilitate the application of the ligature without constituting any very serious impediment to the subsequent progress of the case.

Le Fort[1] recites 71 instances of ligation of the subclavian for axillary aneurysm. Of these cases, 45 were cured, 24 died; in 2 the result is unknown. Of the 24 deaths, 7 were due to secondary hemorrhage, and 5 to suppuration or rupture of the sac.

Barwell[2] gives 90 cases, with 32 deaths. Of the deaths, 10 were due to secondary hemorrhage, 10 to suppuration of the sac, and the remaining 12 to pyæmia, pulmonary complications, exhaustion, etc. Delbet[3] has collected 12 cases of incision of the sac, with 10 cures and 2 deaths.

This method will be confined to cases where diffusion of the aneurysm and inflammation of the sac has occurred and when the aneurysm is situated in the third portion of the artery. Excision of the sac may be practised when the aneurysm is low down, of small size, but yet causes severe pain or paralysis.

Subclavian Aneurysms.

The right subclavian artery arises opposite the sterno-clavicular joint from the innominate. It arches over the apex of the lung, and crosses

[1] Le Fort, *Dict. Encycloped.*, art. "Axillaires (Vaisseaux)."
[2] Barwell, *Internat. Encycl. of Surg.*, Ashhurst, vol. iii., art. "Aneurysm."
[3] Delbet, "Traitement des Anévrysmes externes," *Revue de Chir.*, 1888-89.

the first rib between the anterior and middle scaleni muscles to become the axillary.

In the first part of its course the artery rests upon the pleura. In front of it are various muscles, the internal jugular and vertebral veins, the pneumogastric, phrenic, and cardiac nerves. Posteriorly lie the recurrent laryngeal and sympathetic nerves, the former turning around the artery from in front and below. The second portion lies between the middle and anterior scaleni, the latter of which separates the artery from the subclavian vein. Above it is the brachial plexus; below, the pleura. The third portion lies upon the first rib in the subclavian triangle. Above it is the brachial plexus; in front, besides several small vessels, is the subclavian vein.

The left subclavian arises from the arch of the aorta, and passes almost vertically upward to the margin of the first rib, over which it crosses to become the axillary, just as does the right subclavian. The first portion of the left subclavian, then, lies within the thorax, behind the pleura and lung, the left carotid, the left internal jugular and innominate veins, the pneumogastric and phrenic nerves. To the outer side is the pleura. To the inner side are the trachea, œsophagus, and thoracic duct. Behind the vessel lie the œsophagus and thoracic duct, the vertebral column, etc.

Lesions.—Subclavian aneurysm may develop from any portion of the artery, but most frequently springs from the first, next from the third, while the second part is rarely affected unless the entire artery be dilated or it is involved in aneurysms originating in the first or third portion.

Aneurysm of the first part of the right subclavian not infrequently merges into innominate aneurysm, while the corresponding portion of the left side is seldom affected. Aneurysm of the first part of either side is usually sacciform, and may reach considerable size. The clavicle may be eroded or even dislocated at its sternal end. If the internal jugular vein be compressed, cyanosis or œdema of the face is present, and the external jugular distended. Compression of the subclavian veins causes œdema of the shoulder and arm.

The recurrent laryngeal nerve may be involved if the aneurysm be one of the right side, and cough and change of voice, or even aphonia, ensue. The pleura and lung may be encroached upon and pneumonia supervene. Rupture of the sac may occur through the skin or into the pleural cavity or the lung.

Aneurysms of the third portion develop in the subclavian triangle, and sometimes involve the upper part of the axillary. Pressure-effects are due to encroachments upon the brachial plexus, giving rise to pain and paralysis in the upper extremity, to compression of the neighboring vein, and to œdema in the same limb.

The aneurysm is usually of moderate size and sacciform.

Etiology.—The subclavian was the site of aneurysm 23 times in Crisp's group of 551 cases. It is more frequent in men than in women, the proportion stated by Erichsen being 15 to 1. The right side is affected three times as often as the left. Wounds and contusions have been mentioned as preceding the development of aneurysm of the subclavian.

In the spontaneously-arising aneurysms endarteritis doubtless plays the usual rôle. The existence of a cervical rib has been alleged to have excited the formation of aneurysm in the neighboring subclavian.

Symptoms.—The most prominent symptoms of aneurysm of the first part of the subclavian are due to pressure upon the neighboring structures, and of these dyspnœa, due to compression of the trachea or the recurrent laryngeal, is the most distressing.

With aneurysm of any part of the artery œdema and pain are usually present. Pain is especially marked in cases of aneurysm of the third part, where the brachial plexus is encroached upon. Aneurysm of the first portion forms a tumor behind the clavicular origin of the sterno-mastoid and immediately above the clavicle. Its long axis is horizontal or oblique, and the characteristic pulsation, thrill, and murmur are commonly present.

The corresponding radial pulse is changed in character; and the temporal pulse is sometimes diminished in force, as a consequence of compression of the carotid at its origin by the sac, but its character is not aneurysmal.

Aneurysms of the third part present in the subclavian triangle, where they show, upon examination, the features usually found in superficial aneurysms.

The **diagnosis** will be discussed under Aneurysms of the Innominate.

Prognosis.—Spontaneous cure has been observed. The disease progresses slowly, as a rule, to a fatal issue. Death is usually caused by rupture of the sac externally or into the pleural cavity or lung.

Treatment.—Medical means will naturally be resorted to in preference to operation, especially in aneurysms of the first portion of the subclavian. Decubitus and restricted diet, together with the administration of potassium iodide, have yielded seven successful results, according to Poinsot.[1] The operative treatment of aneurysms of the first part of the subclavian has so far been far from successful.

Distal ligation, when one considers the slight restriction of the circulation effected thereby because of the numerous branches given off from the first and second portions of the artery, does not hold out much promise. The alternatives are ligation of the first part of the artery, with simultaneous ligation of the vertebral and ligature of the innominate. Of the former operation Barwell[2] has collected 15 instances, with 12 deaths, and of the latter 23, with 22 deaths. Yet, as this author remarks, these operations were done without the conspicuous advantage of absorbable ligatures, and he further says that he would not, under modern conditions, decline to tie either vessel were the case a suitable one.

Macewen's[3] method, needling, would, however, seem to be the procedure of choice. In the very unpromising case reported by him the result was eminently successful. The patient, a woman æt. forty-four, had an aneurysm of the first part of the left subclavian, found on introduction of the needle to be about four inches in diameter. She suffered severely from pain referred to the corresponding arm and shoulder, from

[1] Poinsot, *Dict. de Méd. et de Chir. prat.*, art. "Sous-clavière Innominée," vol. xxxiii.
[2] Barwell, *Internat. Encycl. of Surg.*, Ashhurst, vol. iii., art. "Aneurism."
[3] Macewen, *Brit. Med. Journ.*, 1890, ii. pp. 1107–1164.

great œdema of the limb, and from paresis of its muscles. She coughed and had dyspnœa. The needle was passed through the sac to, but not into, the opposite wall, and allowed to remain for nine hours, the position being changed from time to time and allowed to move as the blood-current affected it. This was repeated three times at intervals of four, fourteen, and seven days. Marked increase in the thickness of the sac followed, with considerable relief of the symptoms, and treatment was suspended for four months, during which thickening of the aneurysm's walls progressed. The needle was introduced five times afterward, till a cavity could no longer be recognized. A year after the first needling the aneurysm seemed consolidated and the tumor had greatly diminished, œdema disappeared and pain ceased, muscular power in the arm returned, and the patient was cured. Pulsation in the radial was absent.

To recapitulate: For aneurysms of the first portion of the subclavian one should first employ medical methods; these failing, needling should be undertaken; and only as a last resort in case of advancing symptoms should ligation be contemplated.

In rare cases aneurysm of the third portion of the artery has been cured by direct compression by means of pads, either alone or supplementing Valsalva's method. Manipulation has been practised with occasional success. Amputation at the shoulder-joint has been done without success.

In one case, that of Syme, operation by Antyllus's method was performed with success. In another instance destruction of the sac was accomplished by caustics and the patient cured. Excision has been performed in one case, that of Halsted.[1] It is hardly a fair example, however, for the aneurysm was of the subclavio-axillary variety, and had progressed far toward spontaneous cure, as was indicated before the operation by the almost complete absence of pulsation, and demonstrated afterward on examination of the sac. About two inches of the axillary vein and nearly the whole clavicle and part of the deltoid muscle were removed with the sac. The subclavian artery was tied "in the beginning of its second part." The case shows that aneurysms presenting in the subclavian triangle may be extirpated, that injury of the vein is not necessarily succeeded by disaster, and that ligation of the second part of the artery may be accomplished with success.

Of the ligating operations, distal ligation would not promise success, owing to the free anastomotic circulation.

Proximate ligation may be done close to the sac, upon the third or second portions or upon the first portion of the artery or the innominate.

Ligation of the third part has been rarely successful, save where the aneurysm was of the subclavio-axillary variety.

Ligature of the second part has been infrequently done, but with moderate success, and is to be recommended in proper cases. The second part gives off but a single branch, as a rule; it is accessible through an external incision of proper size and position.

Ligation of the first part of the subclavian has been fatal in the vast majority of cases. Death has regularly been due to secondary hemorrhage and from the peripheral end of the vessel divided by traction upon the insoluble ligature. Opinion inclines to the belief that ligation

[1] Halsted, *Bull. Johns-Hopkins Hosp.*, September, 1892.

performed under aseptic conditions, with soluble ligatures and without suppurative accidents, would prove successful.

Operative treatment of aneurysm of the third portion of the artery, then, may be undertaken as follows: Expose the sac by a free horizontal incision and explore its proximal aspect. If the artery in its third or second parts is found suitable for ligation, the ligature may be applied. If, on the other hand, these portions are too extensively diseased or inaccessible, prolong the incision toward the median line, add a vertical incision along the anterior border of the sterno-mastoid, and proceed to expose and tie the first part and the vertebral. Make every effort to secure primary union.

Innominate Aneurysm.

The innominate artery rises from the transverse portion of the arch of the aorta in front of the left common carotid. It passes upward to the level of the right sterno-clavicular joint, where it divides into the right carotid and subclavian arteries.

The innominate is separated from the manubrium sterni by the origins of the pretracheal muscles and by the left innominate and inferior thyroid veins. Behind it lies upon the trachea. To the right are the pleura, the right innominate vein, and pneumogastric. To the left is the left carotid.

Lesions.—The aneurysm may be confined to the innominate itself, or it may be developed at the upper end of the artery and involve the subclavian or carotid, or both, to a variable extent, or, finally, it may arise at the origin of the innominate and implicate the arch of the aorta.

The aneurysm is oftenest sacciform, but may be fusiform. In size the aneurysm varies within considerable limits. It may remain confined to the thorax or extend into the neck, and in the latter situation may send diverticula in a variety of directions. The aneurysm may compress the heart and the aorta. The innominate veins and the superior cava may be encroached upon, and also the internal jugular and subclavian veins, and where so compressed the veins may be obliterated. Obliteration of either or both the afferent trunks has been observed.

Compression and ulceration of the œsophagus and trachea may occur, and the development of broncho-pneumonia has been ascribed to pressure upon the pneumogastric nerve.

The sternum, ribs, and vertebræ may be eroded and the clavicle displaced.

Etiology.—In Crisp's group of 551 aneurysms 20 occurred in connection with the innominate.

Innominate aneurysm occurs more frequently in the male than in the female.

Symptoms.—The existence of innominate aneurysm oftenest attracts attention by the development of symptoms referable to compression of one of the neighboring viscera. Dyspnœa is most frequently complained of.

Symptoms of this character are succeeded by the appearance of the tumor itself. The latter is usually recognized behind the right border of the first piece of the sternum by dulness, thrill, or bruit. Subsequently the aneurysm may be confined to the thorax, eroding the ribs, sternum, or vertebræ, or it may ascend and appear above the suprasternal notch, where it will be accessible to examination.

With the growth of the tumor the pressure-symptoms are added to and increased, and dyspnœa, dysphagia, hoarseness, œdema, pain, and paralysis develop.

Prognosis.—Spontaneous cure by obliteration of the efferent vessels has been rarely seen. The course of the disease is progressive. Death is due usually to rupture of the sac externally or into the trachea, œsophagus, lung, or pleura; or obstruction of the œsophagus may be complete enough to result in death from inanition.

Diagnosis.—Aneurysm at the root of the neck may be either aortic, innominate, carotid, or subclavian.

The history of the point of appearance of the tumor, the direction of its growth, the direction of conduction of the bruit, and the sphygmographic tracings of the various interested arteries should serve to distinguish the origin of the aneurysm.

Treatment.—The so-called medical treatment has yielded not a few successful results. Continuous decubitus; a diet rigorously restricted, particularly as to the amount of fluids taken, associated with the exhibition of potassium iodide, and bleeding if plethora be present, should always precede any more radical measures. The injection of coagulating substances, galvano-puncture, the introduction of foreign bodies, are mentioned only to testify to their inefficiency or danger.

Proximal ligature of the innominate has been undertaken, and of the 3 cases collected by Le Fort[1] 1 recovered. The procedure, from its intrinsic difficulties and dangers, will rarely be undertaken, nor can it be recommended.

Distal ligation of the carotid or the subclavian, or of both, either simultaneously or successively, may be employed. Of these, simultaneous ligation of the carotid and subclavian, third portion, has most frequently been undertaken.

Walther[2] has added 3 cases to the group of 32 previously collected by Wharton[3] and Poinsot.[4] Of the 35 cases, 14 were cured. Poinsot reported 23 cases in 1882, with 8 cures and 5 deaths. Since 1882, 12 cases have been reported, with 10 favorable results.

If failure follow from the application of the ligature to the carotid and the subclavian, and if the tumor persists or increases in size, then the method advocated by Macewen[5] may be undertaken. In the hands of Macewen and other Scotch surgeons[6] the procedure has been attended by success.

[1] Le Fort, *Dict. Encycl. des Sc. méd.*, art. "Brachio-céphalique," vol. x. p. 452.
[2] Walther, *Traité de Chir.*, Duplay et Reclus, vol. v. p. 751.
[3] Wharton, *Journ. Am. Med. Assoc.*, 1887, viii. p. 457.
[4] Poinsot, *Dict. de Méd. et Chir. prat.*, art. "Sous-clavière Innominée," vol. xxxiii.
[5] Macewen, *Brit. Med. Journ.*, 1890, ii. pp. 1107–1164.
[6] Thompson, *Glasgow Med. Journ.*, 1891, p. 453; Buchanan, *ibid.*, xxvi. p. 280.

Carotid Aneurysm.

I. Common Carotid.

The right and left common carotids differ in their origin (the left arising from the arch of the aorta, and the right from the innominate) and in their length. In the neck, however, they are substantially symmetrical. The vessels extend from the level of the sterno-clavicular joint to that of the superior border of the thyroid cartilage. Posteriorly, the artery rests upon the longus colli and the rectus capitis anticus major. The inferior thyroid with the recurrent laryngeal nerve passes behind the carotid. The cervical sympathetic lies posterior to the vessel throughout its course.

Internally, the carotid is in relation with the trachea, larynx, and pharynx. Externally, and lying in a sheath common to it and the artery, descends the internal jugular vein, while also within the sheath, between the artery and vein, but in a plane posterior to both, lies the pneumogastric nerve. Overlying the artery are the integument and fasciæ, sterno-mastoid, sterno-hyoid, sterno-thyroid, and omo-hyoid muscles, and upon the anterior surface of the sheath is the descendens noni nerve.

Lesions.—The right carotid is the site of aneurysm oftener than the left. The disease may affect any part of the vessel, but the extremities are more often involved than the central portion, and of the extremities the superior is more frequently the seat of aneurysm than the inferior.

In size this aneurysm is usually small, though some of considerable volume have been reported. The organs in relation with the vessel may be encroached upon by the sac and their functions interfered with. Erosion of the cartilages of the larynx and trachea has been described. Flattening of contiguous nerves with abolition of their functions is found.

The separation of clots from the interior of the sac may cause embolism of the brain. The sac may rupture into the trachea, œsophagus, or pleura, or externally through the skin.

Etiology.—Carotid aneurysm has been alleged to occur as often in women as in men. Pilz[1] gives the ratio of 55 males to 28 females in 83 cases. It has been observed at ages of ten, eighteen, and twenty-five years. In Crisp's group of 551 aneurysms there are 25 cases of carotid disease.

Carotid aneurysm probably owes its origin to endarteritis, whether due to syphilis, gout, rheumatism, alcoholism, or nephritis.

Symptoms.—The symptoms vary greatly according to the position of the aneurysm. In general, the neck at the site of the developing tumor is painful. Pulsation increases, and finally the swelling appears. There may be cerebral symptoms of various kinds and degrees, due to irregularity in cerebral circulation. Pressure-symptoms when the superior extremity of the artery is affected are the result of compression of the internal jugular, giving rise to cerebral and ocular symptoms; compression of the pharynx, causing dysphagia; displacement or erosion of the larynx, causing dyspnœa and changes in the voice.

At the lower end of the artery aneurysm exerts the same effect upon

[1] Pilz, *Arch. f. klin. Chir.*, 1857, ix. p. 257.

the jugular as the above. Encroachment on the œsophagus excites dysphagia; upon the trachea, dyspnœa; upon the recurrent laryngeal nerve, changes in the voice, but this is rare.

In aneurysm of any portion of the artery the branches of the cervical plexus and brachial plexus may be compressed, causing pain, paræsthesia, or paralysis.

The **diagnosis** of carotid aneurysm may be attended with considerable difficulty. It must be distinguished from large lymph-nodes, thyroid tumors, phlegmons, and at the root of the neck from other aneurysms presenting there.

In most cases carotid aneurysms, particularly those of the upper end, are of slow growth. They are very rarely spontaneously cured. When fatal, death has been due to asphyxia, to cerebral accidents, to rupture of the sac.

Prognosis.—The aneurysm may remain stationary for long periods, but because of the constant danger of cerebral embolism interference should be undertaken if the aneurysm tends to increase or to create dangerous pressure-effects.

Treatment.—Where the aneurysm is situated at the upper part of the artery indirect digital compression may be made in repeated short sittings. The carotid below the sac is usually compressed between the finger and the transverse process of the sixth cervical vertebra. The sessions must be short, for the procedure is exceedingly painful. Such treatment has been successful in a number of cases.

Of the operative measures designed for the cure of aneurysm, the number applicable to carotid aneurysm is small. In addition to incision and excision of the sac, proximal and distal ligature are alone available.

Proximal Ligature Close to the Sac.—Le Fort[1] has collected 34 cases of ligation according to this method. Of these, 16 were cured, 1 relapsed, and 17 died. Of the deaths, 7 occurred with cerebral symptoms, 2 were due to compression of the trachea by the aneurysm, 5 were caused by hemorrhage consequent on rupture, inflammation, or suppuration of the sac, 1 to hemorrhage at the site of ligature, and 1 to exhaustion. Of 9 more recent cases, but 2 died—1 of hemorrhage, the other of suppuration.

It is seen that a considerable number of patients perishing after ligation of the carotid present symptoms referable to changes in the brain, and of these hemiplegia, convulsions, delirium, stupor, vertigo, and syncope constitute the majority. Of these, hemiplegia is by far the most serious; of these cases but a small percentage recover.

The paralysis has occasionally been confined to the face or upper or lower extremity. Autopsy has shown this paralysis to be due to extension of a thrombus from the aneurysm to the brain, with softening of the latter.

Distal ligation is confined to the treatment of aneurysms near the origin of the artery. Le Fort[2] gives 9 cases, with 4 deaths. To this group we add Dittel's[3] case, in which death was caused by hemorrhage, and Delens'[4] successful case, making 11 cases, with 5 deaths.

Incision of the sac will be necessary where rupture, inflammation, or

[1] Le Fort, *Dict. Encycl.*, art. "Carotide," xii. p. 625. [2] *Ibid.*, *loc. cit.*
[3] Dittel, *Weiner med. Woch.*, No. 4, p. 153.
[4] Delens, *Bull. de la Soc. de Chir.*, 5 Nov., 1879, p. 828.

suppuration has occurred or proximal ligation has failed. In the latter case obstruction of the afferent trunk by previous ligation facilitates the operation. Excision of the sac has not yet been reported.

II.—Aneurysm of External Carotid.

Where aneurysm of this vessel occurs close to its origin its distinction from similar disease of the upper end of the common carotid is very difficult, and its treatment is practically the same. Operation, however, is much less dangerous, for death from embolism or thrombus of the brain is much rarer. Combining Le Fort's[1] and Delbet's[2] cases, the group consists of 17 operations, with fatal termination in 3. Of the deaths, 2 were due to cerebral changes.

For aneurysms of the branches of this vessel extirpation would be the method of choice.

III.—Internal Carotid.

Aneurysms of this vessel, occurring outside the skull, usually present in the pharynx, and must always be considered in the diagnosis of tumors in this region and of the tonsil. They give rise to pressure-palsies in the distribution of the pneumogastric, glosso-pharyngeal, and hypoglossal nerves. Their treatment is identical with that of aneurysms of the upper end of the common carotid, with the same risk of cerebral accidents.

Aneurysm of the Arch of the Aorta.

The transverse portion of the aortic arch passes from the second right chondro-sternal articulation, backward and to the left, to the left side of the fourth dorsal vertebra. It passes over the root of the left lung and left inferior laryngeal nerve. In front of it are the pleura and lung. Posteriorly, the trachea, œsophagus, and left recurrent nerve lie close to the aortic arch, while from its superior surface arise the innominate, the left carotid, and left subclavian arteries. The left innominate vein lies in close relation with the arch's upper aspect.

Lesions.—Aneurysm of the horizontal portion of the aortic arch may be fusiform or sacculated; the larger number are sacculated. The greater proportion arise from the posterior surface, and a smaller from the anterior or upper surface. Those given off from the posterior surface are apt to compress or erode the trachea or œsophagus. Those originating from the anterior or upper aspect soon affect the veins and arteries of the region, and may invade the neck above the sternum.

The aneurysm may rupture externally into the pericardium, pleura, bronchus, trachea, œsophagus, or a neighboring vessel.

Symptoms.—Those aneurysms given off from the posterior surface of the arch are apt to give rise to symptoms due to compression of the trachea, œsophagus, or recurrent nerve before the physical signs disclose the existence of a tumor. Those given off from the upper or anterior aspects of this portion of the arch give the signs of tumor before marked

[1] Le Fort, *loc. cit.* [2] Delbet, "Traitement des Anév. ext.," *Rêvue de Chir.*, 1888–89.

pressure-symptoms supervene. When the aneurysm has reached some size there are regularly present cough, dyspnœa, hoarseness, dysphagia, pain, and tumor; there may be œdema of the face, neck, or arms. The tumor presents either in the suprasternal notch or behind the manubrium to the right or left of the median line.

Murmur is not always present.

Within the past few years an important diagnostic symptom of aneurysm of the arch of the aorta has been described under the title of "tracheal tug."[1] It occurs with those aneurysms of the arch of the aorta whose growth is downward or backward, and which encroach upon the left bronchus or that part of the trachea close to its bifurcation.

In the presence of an aneurysm of such character, by elevating the patient's chin and grasping the cricoid cartilage a distinct tug is recognized as occurring at each systole of the heart. The chief value of this sign lies in the fact that it is absent in cases of pure innominate aneurysm, which otherwise might be confounded with those of the arch.

Prognosis.—A certain number of cases recover spontaneously or as the result of treatment, but in most instances the disease progresses to a fatal termination by rupture or interference with respiration.

Treatment.—Medical treatment by the method of Valsalva constitutes the chief reliance in the treatment of this form of aneurysm, and must be carried out with the most rigorous attention to detail. In a number of cases cure or prolonged relief of symptoms has been effected by ligating operations upon the vessels of the neck. Possibly the arteries tied in those cases were implicated in the aneurysm of the arch at or near their origins, as changes in their pulses should have shown. These operations have consisted in ligation of the right common carotid, and sometimes also of the right subclavian in its third part when the tumor is mainly on the right side, and of the left common carotid when it is on the left side. The introduction of foreign bodies into the sac (horsehair, iron wire, catgut, etc.) has been done in a few cases, but the result has usually been disastrous.

Orbital Aneurysm.

Anatomy.—The internal carotid artery as it emerges from the carotid canal in the petrous portion of the temporal bone enters the cavernous sinus, within which it passes forward to the anterior clinoid process, where it pierces the dura and divides into its terminal branches.

The ophthalmic artery arises from the internal carotid just as the latter leaves the cavernous sinus, and, passing through the optic foramen, supplies the eye.

The cavernous sinus is the continuation of the ophthalmic vein within the skull, which the latter enters at the sphenoidal fissure. The sinus passes back along the side of the sella Turcica to the apex of the petrous portion of the temporal bone.

Lesions.—Excluding those cases of pulsating exophthalmos due to vascular tumors of the orbit, the lesions upon which this phenomenon depends may be arranged in two groups. In one the lesion is situated in the orbit; in the other, within the cranial cavity.

[1] Sansom, *The Diagnosis of Diseases of the Heart and Thoracic Aorta*, p. 125.

In the orbit a pure sacculated aneurysm of the ophthalmic artery or a cirsoid aneurysm may develop and give rise to a pulsating exophthalmos, but in these cases the veins are not primarily concerned. Within the skull autopsies have shown the symptoms to have been due to aneurysm either of the internal carotid within the cavernous sinus or of the ophthalmic, the consequences of aneurysm in either of these positions being compression of the sinus and dilatation of the orbital veins.

The commonest and most important of all the causes, however, is rupture of the internal carotid into the cavernous sinus, either as the result of disease or as the consequence of injury. In these cases, demonstrated many times at autopsy, the arterial blood finds its way through the rent in the artery into the sinus, reverses the current in the latter and in the ophthalmic vein, distends and dilates them and their tributaries, and finally produces exophthalmos and pulsation of the globe.

In several cases the blood-current has found its way through the circular sinus to the opposite cavernous sinus, and has thus produced bilateral pulsating exophthalmos. As consecutive symptoms paralysis of either the optic nerve or of the motor or sensory nerves of the orbit may occur; inflammations of the eye may ensue; or fatal epistaxis may terminate the life of the patient.

Etiology.—The disease may be of spontaneous origin or due to traumatism.

Rivington,[1] in analyzing the group of 73 cases collected by him, found that 32 were idiopathic and 41 traumatic. Of the traumatic cases, 31 occurred in males, and among the 41 traumatic cases, 27 concerned the left orbit, 10 the right, 3 were bilateral, 1 not stated. Of the 32 idiopathic cases, 21 occurred in females. Of the traumatic cases, 13 were due to blows, 19 to falls, 5 to penetrating wounds of the orbit, 1 to a blow upon the nape of the neck, the others to miscellaneous injuries of the head; and of these cases, 33 were almost certainly fractures of the base of the skull. Of the idiopathic cases, several are ascribed to the efforts of parturition or developed independent of extraordinary effort during pregnancy; in others no direct cause could be discovered. Indeed, in two instances the patients were roused from sleep by the pain, which probably indicated rupture of the artery and the circulatory disturbance.

Symptoms.—The symptoms vary widely in their initiation according as the case is one of spontaneous origin or the consequence of injury, and further differ with the lesion giving rise to the symptoms.

In those cases developing as the result of slowly-increasing aneurysms within the orbit or the cranium the symptoms are naturally much more gradual in their appearance, and differ from the cases of arterio-venous aneurysm in the extent and character of the changes in the veins.

In idiopathic cases dependent upon rupture of the internal carotid the first symptom is usually some abnormal, and often very painful, sensation felt in the affected side of the head, accompanied by a loud crash or report, and succeeded by a continuous bruit which varies greatly. In other instances these preliminary symptoms are not observed.

In the traumatic cases the first symptoms are usually obscured by those of the injury causing the rupture of the internal carotid, as frac-

[1] Rivington, *Medico-Chirurgical Transactions*, vol. lviii. p. 208.

ture of the base of the skull. After the condition is more established the symptoms of both classes are much alike.

The period required for any considerable development of the disease is almost always several weeks, and in not a few cases has been several months, and cases have varied as to the sequence of the symptoms. In some cases exophthalmos has preceded pulsation and paralysis, and in others the reverse has occurred.

The most conspicuous effect is exophthalmos, and this may be of slight or very great extent. The axis of the eye deviates somewhat in most cases as the result of paralysis of the ocular muscles, and for the same reason movements of the globe are limited or absent. The lids are swollen by the distended veins, and are either darkish or flushed, and the inner part of the upper lid regularly presents a pulsating tumor of variable size at the junction of the frontal and supraorbital veins to form the angular; and in a few cases the dilatation and pulsation of the former veins may be traced upon the forehead. The conjunctiva is chemotic, and is sometimes so swollen as to evert the lower lid. The pupil reacts sluggishly. The cornea may become the site of opacities or ulceration at a late stage of the disease.

Pulsation of the globe is marked, and is visible as a rule, but is especially apparent upon palpation.

The tumors formed by the dilated and distorted veins, especially in the upper lid, present the characters usually found in aneurysmal varices in other situations: they are soft and reducible; they possess a distinct pulsation and thrill; and upon application of the stethoscope a bruit is audible. The bruit is peculiar, inasmuch as it is continuous, with exacerbations corresponding to the cardiac systole. Compression of the carotid upon the affected side, or rarely upon the opposite side, diminishes or suspends pulsation or bruit.

Retinal examination occasionally shows the veins to be dilated and pulsating. Vision is markedly impaired, and may be lost. The patient complains of pain, of the constant noise, and of visual disability.

Prognosis.—Spontaneous cure is very rare. The disease is usually slow in its evolution, and may be attended by a variety of complications. Lesions of the cornea or infective accidents may determine interference under disadvantageous circumstances or result in death. Occasionally fatal epistaxis has occurred.

Treatment.—Sattler's[1] statistics include fifteen instances of cure by means of medical treatment alone. In those cases in which compression of one common carotid suspends pulsation cure may be attempted by indirect digital compression; but where pulsation is arrested only by compression of both carotids, this method is impracticable in most instances.

Indirect compression is difficult in the most favorable cases, for it is very painful and may cause vertigo and alarming syncope.

Of 27 cases where digital compression was practised, Sattler found 5 cures, 18 failures, and in 4 cases the symptoms were relieved. Galvano-puncture and coagulating injections have been made with occasional success. Ligature of the common carotid, supplemented or not by ligature

[1] Sattler, "Ueberpulsiren den Exophthalmos," *Handbuch der Augenheilkunde*, Graefe and Samisch.

of the other carotid, is the procedure of choice. Sattler states that 60 per cent. of the cases so treated were cured, while the mortality of ligation of the carotid, when done for pulsating tumors of the orbit, is 12.7 per cent.—much lower than when performed for other causes.

Extirpation of the contents of the orbit has been proposed as a primary operation, but should be confined to cases that remain unrelieved after indirect compression or ligation of the carotid, and to cases where infection of the orbital contents has occurred.

Aneurysms of the Hand, Forearm, Foot, and Leg.

These aneurysms possess no inherent peculiarities that distinguish them from others.

Those of the hand and forearm may be treated by direct pressure with the Esmarch bandage after Reid's method, or by indirect proximal compression of the brachial. If failure ensue, extirpation may be carried out, and should be preferred to incision, which is apt to leave an annoying scar. In addition, the danger of consecutive hemorrhage is less and prompt healing ensured.

Aneurysms of the foot are best treated by extirpation, but as a preliminary measure Reid's method may be tried.

Aneurysms of the lower half of the leg or of the anterior tibial may be extirpated. Those of the posterior tibial, seated deep in the calf of the leg, approach popliteal aneurysm more closely, and the same principles applicable in the treatment of that disease may be applied to them.

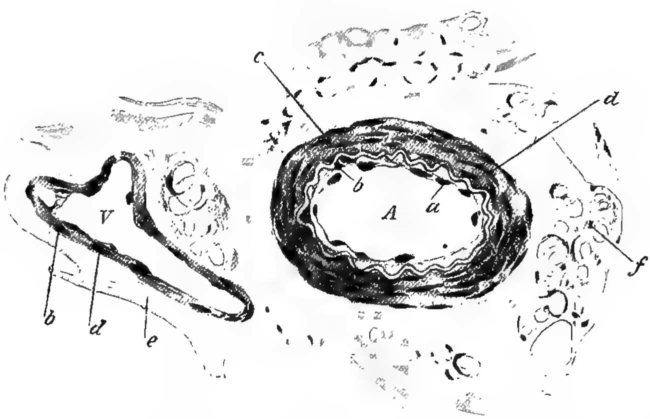
SURGERY OF THE ARTERIES AND VEINS (EXCLUSIVE OF ANEURYSM).

By FREDERIC S. DENNIS, M. D.

Surgery of the Arteries.

Before discussing the surgery of the arteries it is necessary to review a few points in connection with their anatomy. Every artery consists of three separate coats—the *internal coat*, which is called the tunica intima; the *middle coat*, or the tunica muscularis; and the *outer coat*, or the tunica adventitia.

Fig. 366.



Tranverse section of normal artery and vein from the finger of a child: *A*, artery, with (*a*) lining nucleated endothelium resting on a delicate laminated connective tissue; *b*, internal elastic lamina thrown into folds by the contraction of *d*, the thick muscular coat, composed of non-striped muscular fibres, the nuclei of which are seen as deeply stained rod-shaped nuclei; *e*, fibro-cellular adventitia; *V*, vein, with (*a*) flattened endothelial cells, *b*, thin intima; *d*, thin muscular coat; *e*, fibro-cellular adventitia; *f*, fatty tissue. Stained with picro-carmine. × 150.

The *internal* or *serous coat* is a moist, smooth membrane which lines the interior of the heart and the entire arterio-venous system, and finally forms the only coat which the capillary system possesses.

This endothelial coat possesses no blood-vessels, and derives its vascular supply from the middle coat, which in turn receives its nutrition from the vessels of the external coat. The tunica intima is so closely connected with the next or middle coat that it is very difficult to separate them, even by careful dissection, and then only in some of the larger vessels. If traction is made on an artery, the internal coat stretches with the middle coat, but does not rupture. If transverse pressure is applied over a certain area of extent, the artery will not rupture. If a

thin silk ligature is tied around the artery and suddenly tightened, the internal and middle coats will snap and curl up within the lumen of the artery.

The *middle coat*, or tunica muscularis, is the muscular coat that gives to the artery its round symmetrical form and its wonderful elasticity. The arrangement of the muscular fibres is circular. If an artery is cut transversely, the vessel remains patent and does not collapse, like a vein. The veins of the liver, however, form an exception. The circular muscular fibres give to the arteries firmness and prevent any distention along their course. If it were not for the circular coat, the force of the heart driving the blood through the arteries would act more upon some parts than upon others, and would give to the artery a beaded appearance. This pathological condition would soon lead to the formation of aneurysm.

This is an important feature in considering the anatomy of the arteries, since in disease affecting the middle coat distention of the vessel occurs under precisely these conditions: The artery, no longer capable of contracting upon the blood within the lumen, dilates, and in consequence an aneurysm is developed. While the middle coat has an important function in offering resistance to the blood-pressure, still a tight ligature ruptures it instantly, together with the internal coat. Strong traction upon an artery in its long axis will separate the circular fibres and leave a weak spot liable to dilatation, leading to the formation of an aneurysm.

The *external coat*, or tunica adventitia, is a tough membranous sheath. It is composed of fibro-cellular tissue whose fibres are arranged in an oblique, transverse, and circular manner. The external coat is very vascular, as well as highly sensitive, since it is abundantly supplied with vessels and nerves. This coat is of great surgical importance, because the middle and internal coats derive their vascular supply from the external coat. In all operations upon the arteries this coat should be disturbed as little as possible, since any injury to it impairs the vitality of all the coats and increases the dangers of ulceration, which would lead to secondary hemorrhage.

Outside of the three coats of an artery the vessel lies imbedded in loose connective tissue, which separates the vessels from the surrounding structures. This cellular tissue also should be as little disturbed as possible, since a cellulitis might follow any operative procedures upon the vessels, which might also give rise to secondary hemorrhage.

The surgery of the arteries may be divided into *injuries*, *diseases*, and *tumors*. The *injuries* of arteries are discussed in the article upon Minor Surgery, where a full description of wounds of arteries in connection with hemorrhage is given.

Tumors of the arteries are considered under Aneurysm, for a full description of which the reader is referred to the article devoted to that subject.

The *diseases* of arteries which interest the surgeon are chiefly those concerned with the different varieties of inflammation.

There are many theories concerning the cause of thickening of the walls of an artery. Rokitansky claimed that the sclerosis was due to a deposit from the blood on account of some altered condition of the fluid. This view he abandoned to teach the theory that the thickening was due

to an inflammatory hypertrophy with exudation. Virchow held the view that the cells forming the exudative material were derived from a proliferation of the intima-cells, while other pathologists ascribed the origin to the emigration of leucocytes from the blood within the lumen of the artery or from the vasa vasorum. Still, again, other pathologists believe that the sclerosis may be due to syphilis when the evidences of this disease are present in structures and organs in the vicinity of the affected vessel, or to tuberculosis if the bacilli of tuberculosis are found in the external coat or the perivascular tissues.

Thoma has demonstrated that "some change in the blood-current in an artery must result from an extensive destruction of its capillaries;" that whenever the blood-stream was slow the middle coat contracted; and that when this did not occur a new growth of connective tissue developed in the tunica intima, which thus reduced the size of the calibre of the artery and restored the normal swiftness of the blood-stream. Thoma maintained that the muscular coat of the artery first became involved, and the loss of elasticity permitted the artery to dilate—that as a result the blood-current became slow, and in consequence of this the vasa vasorum became distended and a new growth appeared in the intima, which evidently was followed by the same process in the other coats. In a most interesting brochure on this subject Peabody gives the table prepared by Sack, in which he gives the relative frequency of arteritis in the different vessels, with 100 as a maximum—the tibialis anticus, 94; ulnar, 92; radial, 79; popliteal, 54; ascending aorta, 58; common carotid, 58; external iliac, 53; abdominal aorta, 52; brachial, 51.

Arteritis in general leads to aneurysm in the following manner: In the first stage the vessel becomes weakened, and any great dilatation will cause the vessel to expand and produce an aneurysm. If no dilatation occurs in this first stage, and the second stage is completed—viz. the period of hypertrophy of the intima—the danger of aneurysm is escaped. It is claimed by Thoma that the period of greatest weakness of the middle coat is about the fortieth year of life, and that if the individual has not subjected his arteries to some unusual violence until after the second stage, the danger of aneurysm is very much lessened. Besides the development of aneurysm, the results of arteritis may be softening of organs, spinal and cerebral hemorrhage, gangrene of the part, thrombosis, and sudden death, which may follow sclerosis.

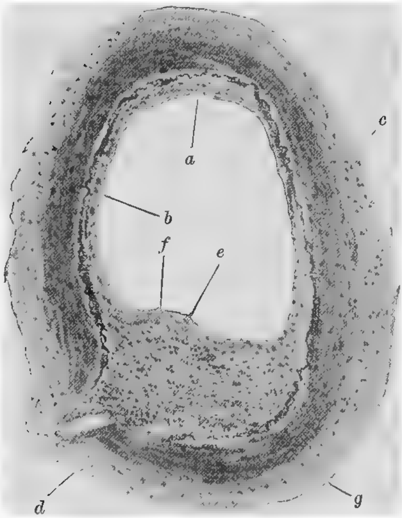
Arteritis may affect any one of the three coats already described. If the arteritis involves the internal coat, the term *endarteritis* is applied; if the middle coat, *mesarteritis;* if the external coat, *periarteritis.* All these varieties may be either acute or chronic.

Acute arteritis is not frequently seen, and is caused by an inflammation produced by an infective embolus. The tunica intima becomes œdematous and infiltrated with pus-cells. The inflammation soon pervades the other coats and an abscess is developed.

Acute periarteritis may be the result of secondary inflammatory changes in the surrounding tissues, or it may be due to the presence of an infective embolus. In the former case an abscess forms in the loose cellular tissue in which the vessel is imbedded, and the inflammatory process extends into the vessel, or an aneurysm may undergo suppuration and pus-cells gain entrance through the blood-current or by the lymph-

channels, and then set up inflammation in the walls of the vessel. In cases of aneurysm the pressure of the sac upon the surrounding parts produces an irritative inflammation, and the tissues, no longer able to resist the power of infection, soon break down and the pyogenic germs multiply and destroy the tissues.

FIG. 367.

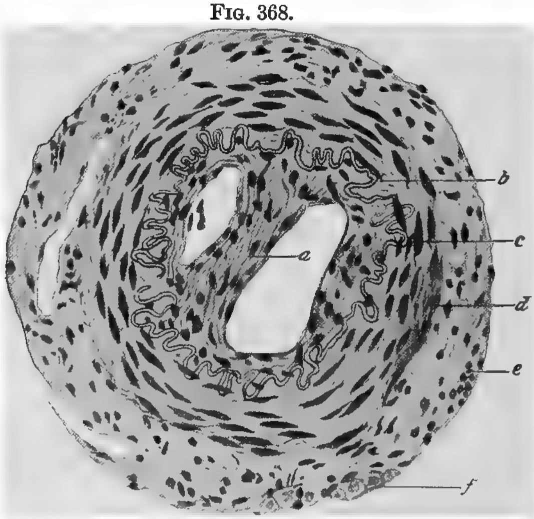


Section of one of the medium-sized cerebral vessels affected with chronic endarteritis deformans (atheroma): *a*, thickened tunica intima; *b*, internal elastic lamina; *c*, muscular tunica media; *d*, tunica adventitia; *e*, endothelial lining covering; *f*, localized thickening of the tunica intima; *g*, two small points at which calcification has occurred. Immediately around the calcareous patches the nuclei are present in considerable numbers. Stained with logwood and eosin. × 40.

In case the acute periarteritis is due to an infective embolus, the progress of the destructive inflammation is very rapid. In any case the artery is generally occluded by a thrombus, so that when ulceration takes place into the lumen of the vessel hemorrhage is not likely to occur. If a thrombus has not formed, and the lumen of the vessel is free, and the artery is of good size, a fatal hemorrhage may follow.

Chronic arteritis is a disease which has chiefly a medical interest. Its surgical bearing is in connection with its relations to the development of aneurysm (Fig. 367). The period at which chronic arteritis or atheroma is most frequently seen is late in adult life or between thirty and forty years of age, and especially in alco-

FIG. 368.



Section of small artery from the boundary-area of the kidney, from a case of subacute interstitial nephritis, well-marked endarteritis obliterans: *a*, enormous thickening of subendothelial and endothelial tissues, the letter pointing to a process passing from wall to wall and dividing the lumen into two channels; *b*, yellow internal elastic lamina; *c*, well-marked muscular coat; *d*, delicate external elastic lamina; *e*, fibro-cellular adventitia increased in thickness; *f*, epithelium of one of the straight tubules. Stained with picro-carmine. × 200.

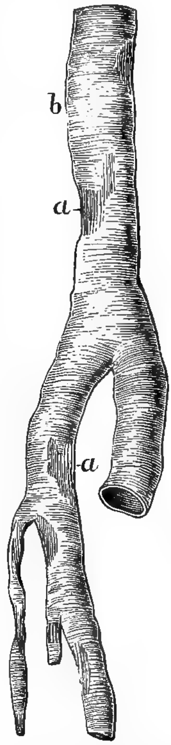
holic patients. In this type of vascular disease the larger arteries are usually involved, whereas in syphilitic arteritis the smaller vessels are chiefly affected. Chronic arteritis is found associated with nephritis, and in patients addicted to alcoholic and venereal excesses; also in those with gouty, rheumatic, and syphilitic diatheses.

The disease may occur in segments of the artery or be seen in small patches. The lumen of the vessel may be partially occluded, owing to the development of new connective tissue. If the hyperplasia is sufficient, the lumen of the artery may be closed, and to this condition the term "endarteritis obliterans" has been applied (Fig. 368).

Chronic arteritis is usually followed by a fatty degeneration of the coats of the vessel, or by a calcification of the walls of the artery, or by atheromatous ulcers along the tunica intima. From these ulcers small particles of tissue are often set free in the vessel and give rise to emboli. In these ulcers lime salts are often deposited, so that calcareous plates are formed along the interior of the vessel.

The *middle coat* may be the seat of inflammation, as a result of which earthy salts, such as carbonate of calcium and the phosphates, are deposited in the tunica muscularis. If the salts are deposited in a ring around the artery, it is termed annular calcification (Fig. 369); if it is spread out over quite an extensive segment of the artery, it is termed tubular calcification; if in patches, it is designated as laminar calcification. The vessel loses its normal elasticity in consequence of the rigidity produced by the deposit of the earthy materials, and the artery feels like a pipe-stem placed under the skin. The vessel soon becomes more or less occluded and gangrene of the extremity ensues.

FIG. 369.



Calcification of the media of the femoral artery, together with its ramifications. Not magnified.

The vessels chiefly affected by chronic arteritis are the aorta and the coronary, iliac, and femoral arteries. These vessels become dilated from increased blood-pressure, the elasticity of the arteries is lost, and this condition often leads to the formation of aneurysm.

Syphilitic arteritis is produced by a specific poison and is characterized by certain special and clinical features. This form of arteritis affects the vessels of small calibre within circumscribed areas, and usually occurs in young people.

The cerebral vessels are chiefly affected, especially those which are derived from the internal carotid artery. Syphilitic arteritis causes partial or complete obliteration of the lumen of the vessel. The constriction in the lumen of the artery is caused by the changes in the tunica intima, which becomes swollen by cell-infiltration.

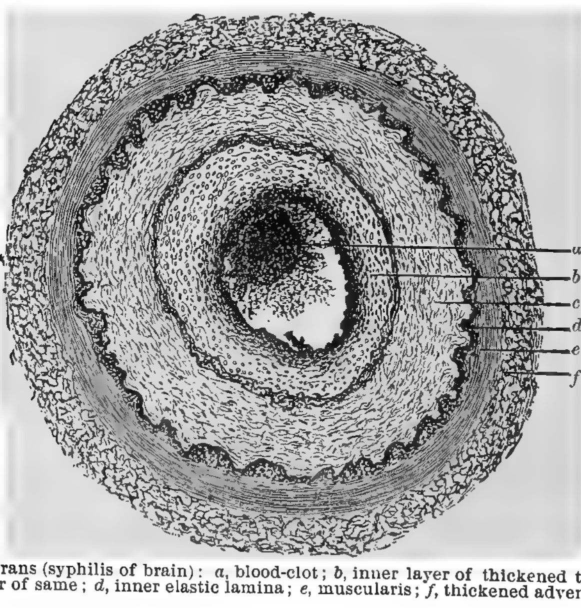
The **treatment** of arteritis is chiefly expectant. The tenderness along the line of the blood-vessel is often relieved by the use of some remedy such as tincture of iodine, with a solution of nitrate of silver twenty grains to the ounce, alternately but simultaneously, painted along the

course of the artery. The limb should be bandaged and rest enjoined until the pain and tenderness have disappeared. In cases of periarteritis

FIG. 370.

Section of cerebral artery, showing syphilitic endarteritis.

FIG. 371.



Arteritis obliterans (syphilis of brain): *a*, blood-clot; *b*, inner layer of thickened tunica intima; *c*, outer layer of same; *d*, inner elastic lamina; *e*, muscularis; *f*, thickened adventitia. × 50.

operative interference is often indicated, and this must be done under the most rigid antiseptic precautions. If the arteritis is due to, or is associated with, any diathesis, like syphilis, gout, or rheumatism, constitutional remedies should be administered. Patients suffering from chronic arteritis should avoid all forms of active or violent exercise, since rupture of the affected vessel is liable to occur.

Surgery of the Veins.

Before considering the surgery of the veins a few remarks upon the anatomy are pertinent. A knowledge of the anatomical peculiarities of the veins will enable the surgeon to appreciate many things in connection with injuries and diseases of these special vessels.

A vein, like an artery, has three distinct coats. The *internal* coat, or tunica intima, is identical with the internal tunic lining the artery. It is a continuation of this coat that forms the network of the capillary system. The tunica intima is composed of an endothelial membrane which is not so thick as in the artery.

The *middle* coat is made up of longitudinal and circular elastic fibres, interwoven among which are found involuntary muscular fibres. The muscular coat in the vein is not as thick or firm as the corresponding coat in the artery, and for this reason the vein lacks the firmness, contractility, and elasticity which are so characteristic of the arteries. The thinness of the muscular coat in the veins permits a bulging of the vessel in certain places whenever there is any mechanical obstruction to the free return of venous blood to the heart. In order to prevent excessive distention of the veins they are supplied with valves which serve to mechanically support the column of blood. These valves are present in the superficial system, particularly in the veins belonging to the lower extremities.

In the portal and hemorrhoidal venous system the valves are absent, which anatomical fact serves to explain the frequency with which these two systems are subject to varices.

The *external* coat is composed of dense white fibrous tissue which is several times thicker than the internal coat.

The surgery of the veins may be divided into *injuries*, *diseases*, and *tumors*. A *wound* of a vein, as far as hemorrhage is concerned, is less dangerous than a wound of an artery of a corresponding size. There are, however, certain inflammatory complications which may attend a wound in a vein which are absent in a corresponding injury to an artery. The hemorrhage from a vein is less than from an artery of the same size, because the vein partially collapses and the force of the circulation is not so great. These two conditions are favorable to the formation of a clot in the wounded vein, which usually collapses; but in addition the vein also retracts and contracts in a slight degree like an artery, so that a coagulum is soon formed at the open mouth of the injured vessel. This clot soon increases in size by the addition of fibrin upon the edge of the wound. In hemorrhage from a vein the blood is extravasated into the surrounding tissues, and thus makes compression upon the walls of the vein, and consequently diminishes the quantity of blood flowing from the wounded vessel.

In cases of avulsion of a limb there is little venous hemorrhage, because the torn veins curl up and clots form at the mouth of the wounded vessel.

The **sign** of venous hemorrhage is the escape of dark-colored blood, which continually wells up from the bottom of the wound in an unbroken stream without rhythmical pulsation. Wounded veins upon the back or side of the thorax often give rise to alarming hemorrhage, since the veins are of large size, and in many cases poorly supplied, if at all, with valves. The respiratory movements of the chest also increase the flow in these parts, and especially in wounds of the veins in the neck. Inspiration holds the venous flow in partial check, because the chest-wall is expanded, while in the expiratory movement the thorax becomes contracted, the large veins at the root of the neck are compressed, and the venous blood is checked in its flow toward the heart, and the blood wells up from the cervical wound. There is immediate arrest of the flow by digital pressure over the distal side of the wound, and immediate return of the flow when the pressure is remitted. The entrance of air into the vein, if situated in the neck, is a most important accident, which demands special attention on account of the immediate danger to life which it produces. The jugular, the subclavian, the axillary, and the thoracic veins, and the cerebral sinuses if wounded, may permit the entrance of air, which may cause immediate death. It is possible for this fatal result to occur without a wound in the vein, as in air-embolism from the uterine sinuses after delivery or from bubbles of gas developed from decomposition in gangrene. The air is carried by suction to the right auricle and ventricle, and here becomes mixed with the blood in these cavities, forming air-emboli. The right heart, incapable of forcing these emboli with the blood through the lungs, leaves the left heart empty, and it at once collapses. In consequence of this inability of the left heart to send blood to the cerebrum fatal syncope follows. In animals injections of air have been made into the circulation without serious disturbance, but in the human being the introduction of air-emboli is usually attended by almost instantaneous death. The entrance of air is accompanied by a sudden heart failure, irregularity of respiration, and dilatation of the pupil, and a churning sound synchronous with the ventricular systole of the heart is heard at the time. These manifestations are usually preceded by a gurgling noise, and in a few seconds convulsions occur, followed by death. In the wound itself bubbles of air are present.

Certain complications often arise after a vein is wounded, among which may be mentioned phlebitis, œdema, thrombosis, embolism, metastatic abscesses, gangrene, and secondary hemorrhage.

The **treatment** of a wound in a vein depends upon the size and situation of the vessel. If the vein is small and also superficial, elevation of the limb, equable pressure upon the distal side, and fixation of the part will suffice. If the vein is large and deeply situated, the injured vessel should be sought after, and both ends of the divided vein secured by an aseptic silk or catgut ligature. If the wounded vein is within one of the three great cavities of the body, an operation of magnitude is indicated in order to reach and control the hemorrhage.

In case a large vein like the femoral or the popliteal is wounded,

Langenbeck has suggested and practised with success the ligation of the corresponding artery. This will arrest at once an alarming hemorrhage from one of the large venous trunks of the extremities.

The treatment of the entrance of air into the veins consists in immediately making digital pressure on the cardiac side of the wounded vein, lowering the head, the hypodermic administration of cardiac stimulants, and the performance of artificial respiration. Water poured immediately into the wound is said to prevent the further ingress of bubbles of air. The wound in the vein should be instantly closed by the surgeon's finger or by a small sponge. Esmarch's bandage can be applied to the extremities with a view to sending the blood to the heart. Inhalation of oxygen has also been suggested. Tracheotomy can be at once performed, and a tube introduced and air blown into the lungs, which will stimulate the pulmonary circulation and force out the air-emboli. In operations upon the neck the surgeon should avoid dividing tissues when tightly stretched, and instruct his assistant to be always ready to make pressure between the wound and the heart in the event of wounding a vein. The handle of the scalpel should be used to tease out tumors or glands, and the use of the knife avoided as far as possible. Butcher of Dublin recommended the use of a temporary silver wire passed beneath the veins, and then compressing the veins by tightening the ligature temporarily over the integument. In case of excision of a large vascular tumor—notably the female breast—this plan can be adopted, since this compression prevents the sudden loss of blood and the entrance of air into the large patulous vessels which go direct to the heart.

Wounds of Special Veins.—A wound of the jugular vein in the lower part of the neck is generally fatal from the loss of blood or from the entrance of air. The direction of the wound influences the immediate prognosis, since a longitudinal slit will not gape so widely as a transverse one, which is held wide open by the action of the deep cervical fascia. If the internal jugular vein is wounded near its entrance into the skull, besides the dangers arising from the loss of blood and the entrance of air there are the additional dangers of septic infection and of venous and sinus thrombosis. In 43 cases of ligation of the internal jugular collected by Gross, only 4 cases terminated fatally, and these from secondary hemorrhage—a cause of death which can be eliminated by rigid enforcement of the great principles of aseptic surgery.

Ulceration into the jugular veins has been often observed as a sequel to scarlet fever. Nearly all the cases occurred in children. Cervical tubercular abscesses may remain indolent for a long while, and then suddenly start up in a phlegmonous manner and perforate into the jugulars. Bonnet of Lyons has suggested the use of the hot iron to arrest the bleeding in these secondary hemorrhages, and also to arrest the phagedenic spread of the inflammation. In the sinus leading to these tuberculous abscesses the bacilli of tuberculosis may be found.

Injuries of the subclavian and axillary veins are also most serious on account of the profuse hemorrhage and the possible entrance of air. Wounds of the femoral and popliteal veins, in addition to the danger from loss of blood in consequence of the size of the vessel, are liable to be followed by gangrene of the extremity.

In ligating veins care should be exercised to completely occlude the

vessel, since secondary hemorrhage, sepsis, and air-embolism have followed careless or incomplete ligation of the vessel. Styptics should not be employed to arrest hemorrhages from veins, since the dangers of inflammation are very great, in addition to the possible formation of septic thrombi and infective emboli.

In the removal of large tumors it becomes often necessary to expose for a considerable space large venous trunks. The formation of thrombosis in the denuded vein has been demonstrated to be the result of unusual violence, in consequence of which an inflammation in the surrounding tissues has been excited. If both of these etiological factors are avoided by care in the operative technique and by rigid asepsis, it has been shown by Pilcher that the dangers of phlebitis and thrombosis are not to be feared by the surgeon. If, however, it has been necessary to disturb the cellular and connective tissues about a vein, or if suppuration previously existed, the better plan is to expose the vein freely and ligate it above and below with catgut, and excise the segment between the ligatures. Even large veins like the internal jugular have been treated after this manner and no unpleasant disturbances have followed, not even as regards the cerebral circulation, owing, without doubt, to the free anastomotic branches, which soon carry the blood back to the heart.

Pilcher and Fowler have demonstrated that the antiseptic catgut causes an absorption of the internal coat at the point of compression, the middle coat falls together and becomes united, and the ligature itself becomes buried in the substance of the external coat, and thus a large vein will become occluded without the intervention of a thrombus.

In lateral wounds of large veins, where a silk ligature might cause irritation if left for an indefinite period, the use of the pressure-forceps has been employed with success. The forceps are left upon the wounded vein for forty-eight hours and then removed. The small canal leading down to the vein will heal immediately upon the withdrawal of the aseptic instrument. Pilcher reports a successful case in which he employed this method on the internal jugular.

Braun has collected 27 cases in which lateral ligature has been tried upon the following veins:

Vessel.	No. of Cases.	Recovered.	Died.
Internal jugular	12	9	3
External jugular	1	1	
Subclavian	1	1	
Axillary	5	5	
Femoral	8	2	6
	27	18	9

The 3 deaths in which the internal jugular was tied by a lateral ligature were caused by secondary hemorrhage; 5 of the 6 deaths following ligature of the femoral were due to pyæmia. Both of these causes of death can be eliminated by aseptic surgery.

Lateral suture has been employed by many surgeons. The editor has collected about twenty successful cases of lateral suture involving the internal jugular, axillary, and femoral veins.

The advantages of lateral suture are very great, since the continuity of the lumen of the vein is not destroyed. This method of treatment can be easily performed, and increases the prospects of healing by pri-

mary intention. The only real disadvantage that has been proved is the danger of secondary hemorrhage, but this can be prevented by the application of antiseptic surgery.

The introduction of anæsthetics and antiseptics has revolutionized the manner of the treatment of wounded veins. Anæsthetics enable the surgeon to dissect down upon a large vessel without fear of wounding important structures on account of the movements of the patient, while antiseptics permit an animal ligature to be applied and buried, in consequence of which primary healing is sure to follow.

The condemnation, therefore, of the operation of lateral ligature to wounded veins is without foundation, since recent statistics demonstrate clearly that the causes of death can be avoided in these days of antiseptic surgery, and that the rules which were set forth by the older surgeons should be disregarded since the employment of antiseptics and anæsthetics.

In a wound of the femoral vein near the saphenous opening ligation of the superficial femoral has been suggested. It is claimed that this operative procedure will permit sufficient blood to enter the extremity, and at the same time provide a way for the collateral venous circulation to return to the heart. The editor has seen, on the other hand, the femoral vein ligated after injury without a simultaneous ligation of the superficial femoral artery, and no ill effects arose. The same is true of the axillary vein.

Rupture of veins may occur in consequence of severe contusions or as a result of pathological changes incident to varicose veins. A venous hæmatoma immediately develops, and the extravasated blood forms a good-sized tumor under the skin. This clot may undergo absorption or it may become organized. Occasionally the blood causes inflammation by tension, and suppuration follows. Operative interference is indicated in these cases in order to make the wound rigidly aseptic, and thus prevent any danger from the formation of septic thrombi from which infective emboli may arise.

The Diseases of Veins are phlebitis, thrombosis, embolism, varices, nævi, aneurysmal varix, and varicose aneurysm.

The profession is indebted to the renowned English surgeon John Hunter for the first contribution to scientific knowledge pertaining to the inflammation of veins. Hunter in 1784 reported his researches and experimental studies on veins.

Phlebitis can be classified in a manner similar to that given for arteritis. If the inflammation involves the tunica intima, the term "endophlebitis" is employed; if the middle coat, "mesophlebitis;" if the external coat, "periphlebitis."

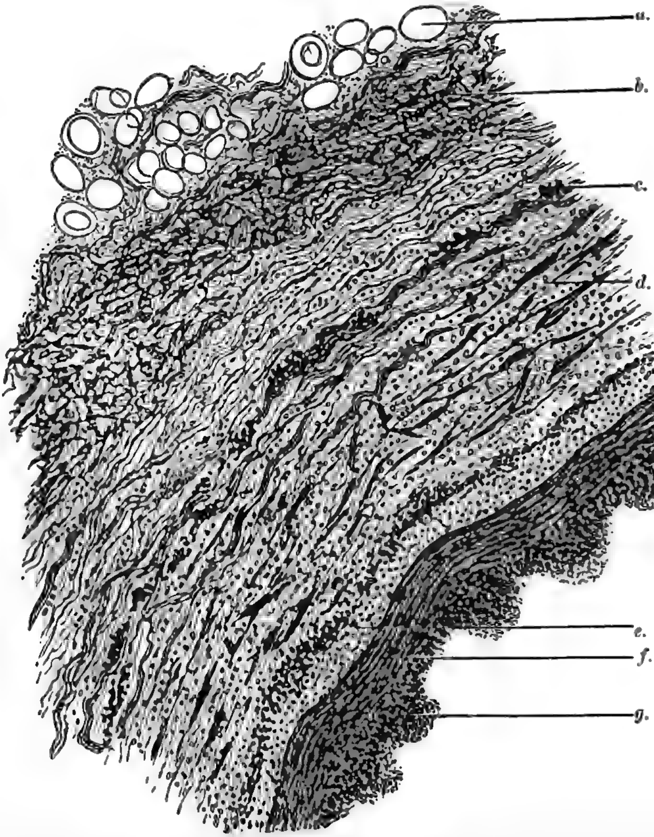
Inflammation of a vein may be confined to a small segment of the vessel or may involve nearly the entire length of the vein. Phlebitis is more frequently observed than arteritis. Inflammation of the vein may be acute, subacute, or chronic.

Acute phlebitis is usually diffuse, and is caused by a suppurative inflammation of the tissues just external to the vessel, by a thrombus, by traumatism, by infection, by severe operations upon the bones, by puncture of the vein, or by ligation in the continuity (Fig. 372). It may follow an amputation or result in consequence of syphilis, gout, rheuma-

tism, or the puerperal state. Acute phlebitis has been compared to an attack of erysipelas of the connective tissue in which the erysipelatous inflammation runs a mild course.

In phlebitis the walls of the vein become thickened, and the tunica intima becomes infiltrated with pus-cells derived from the vasa vasorum.

Fig. 372.



Acute phlebitis, small branch of internal saphenous: *a*, fat-cells; *b*, areolar coat infiltrated with fibrin; *c*, muscular fibres cut across; *d*, small-cell infiltration of wall; *e*, intense small-cell infiltration of tunica intima; *f*, laminated deposit of fibrin; *g*, accumulated leucocytes on same. × 40.

The middle and external coats also become œdematous and infiltrated with pus and serum. Under these circumstances a thrombus forms, and occasionally it so completely blocks the lumen of the vein as to prevent the inflammatory exudates from being carried into the general circulation.

If the thrombus undergoes degeneration and the lumen of the vein is not completely occluded, minute particles of the disintegrated clot may be swept into the circulation, and if septic cause a metastatic abscess, or if non-septic produce a circumscribed area of softening.

Subacute phlebitis is generally circumscribed, and is not so dangerous as acute phlebitis. This variety of phlebitis usually follows some

chronic disease of the coats of the vein in which thickening of the walls by the deposit of fibrinous matter has taken place.

Chronic phlebitis is usually associated with varix of the vein. The process is somewhat similar to that producing atheroma of the arteries. Chronic phlebitis is not so dangerous as a corresponding inflammation of the arteries, since the absence of the same amount of blood-pressure in the vein makes a difference in the clinical manifestations. Chronic phlebitis affects more especially the external coat of the vein. Occasionally there are patches along the internal coat which undergo calcareous degeneration.

The **symptoms** of phlebitis vary according to the variety. In the acute form are present along the course of the vein severe pain and tenderness, and there is œdema of the extremity, with pitting on pressure and with discoloration of the integument lying over the vessel. The superficial veins are distended and full. In case the deep veins, as the common femoral or iliac, are involved, the œdema gives rise to what is known as "white leg." If infection becomes general, there are present rapid, irritable pulse, elevation of temperature, chills, dry tongue, great restlessness, and sometimes delirium, with severe pain in the joints. In the *subacute* form the pain and tenderness are more or less circumscribed, œdema of the extremity is not likely to occur, and the skin-discoloration is limited to the vicinity of the affected segment of the vein. The pulse is not so rapid, and the temperature is lower than in the acute forms, and rigors may or may not usher in the disease. In the *chronic* form of phlebitis pain and tenderness are present, but they are limited to the affected segments of the vein. The discoloration is present, but it appears in patches along the course of the vein, especially at those places where the presence of valves has caused an exaggerated local inflammation.

There is little or no constitutional disturbance in this variety of phlebitis, since it is a very common complication in varicose veins. In all forms of phlebitis the vein feels like a knotted cord, and may lie superficially upon the limb or be imbedded in inflamed and indurated tissue. If the affected limb is permitted to hang down, there is a sense of weight and pain, which is at once relieved if the limb is placed in the horizontal position, and the dilated, engorged, and tortuous veins become at once less prominent.

Phlebitis must not be mistaken for lymphangitis, in which the skin has a brighter coloring along the track of the lymph-channels, and with which an adenitis is associated. *Phlebitis* must also be differentiated from inflammation of the nerves, in which no œdema is present, and, again, from *neuralgia*, in which the pain shows paroxysms and is relieved instead of increased by pressure applied over the limb. The pain in neuralgia is sharp, darting, and stabbing in character. The skin too is sensitive to slight touch, but not to firm pressure. The pain in neuralgia is apt to be increased at night, and often shows some periodicity.

The **treatment** of phlebitis consists in keeping the patient absolutely quiet, especially in the acute form. The object of this measure is to prevent the formation of an embolus, which might cause sudden death. The limb should be elevated to favor the return circulation in the extremity and to relieve the tension. Blisters have also been employed,

and a solution of iodine painted along the course of the vein, over which a solution of nitrate of silver (20 grains to the ounce) is applied in stripes or transverse bands. Lead-and-opium wash can be applied to the limb over the track of the vessel, and over the lint saturated with the wash oil-silk placed so as to prevent too rapid evaporation. Equal parts of extract of belladonna and glycerin, also Goulard's extract, have been recommended.

In case an abscess forms in connection with the phlebitis, it should be incised early and under rigid antiseptic precautions, since the microbes of suppuration and the ptomaïnes may cause the thrombus in the vein to disintegrate and soften, and pieces of the clot with the micro-organisms may enter into the circulation and produce pyæmia. In these circumscribed abscesses in connection with phlebitis hemorrhage is usually absent, since the lumen of the vein has been blocked by the thrombus, with an adhesive phlebitis, as well as by external pressure of the pus upon the vessel. In case the superficial vein is involved, the prevention of septic infection and the dangers of emboli can be averted by an operation suggested by Mr. Lea, in which a needle is passed beneath the vein above and below the thrombus and the vein divided. If the deep veins are involved and the septic thrombus is causing the symptoms of pyæmia, amputation above the inflamed area is indicated to save life. The operation to be successful must be performed early, before the constitutional symptoms are well marked, and with every possible antiseptic precaution. Fortunately, however, such an emergency seldom arises.

In addition to the local measures mentioned and the employment of operative interference, the patient's general condition must be maintained by a free and nutritious diet, by fresh air and tonics, and by judicious stimulation. The surgeon must not overlook the fact that great prostration often accompanies phlebitis, and measures directed to maintain the strength of the patient from the outset must be rigidly enforced.

If syphilis, gout, or rheumatism complicates or causes the phlebitis, specific remedies should be freely administered, as marked improvement under these conditions often follows the employment of these drugs. After the pain and tenderness and all other symptoms have subsided gentle exercise is to be recommended. Massage should be employed with great care if at all, since the friction might inflame the veins or possibly disturb or disintegrate the thrombi. If a varicose ulcer is associated with the phlebitis, the patient should be kept confined to the bed until by proper means the ulcer is healed, after which an elastic stocking should be worn to prevent a return of the ulcer. During the acute attack the administration of antipyretics, the use of saline cathartics, the employment of iron in some form, and the administration of a diaphoretic are urgently demanded. The use of quinine in large doses has been greatly extolled in phlebitis, not only on account of its antipyretic properties, but because the drug is supposed to possess an inhibitory influence upon the emigration of the leucocytes.

Electricity is often of very great benefit as a local tonic to the muscles, which in consequence of disuse have undergone a certain amount of atrophy. Strychnia is an excellent general tonic to stimulate the heart and improve the circulation. The patient should not be allowed to go about too soon after an attack of phlebitis, for fear of the imme-

diate danger of embolism or of the return of the disease. The use of all tight bands like garters should be discontinued, and nothing worn which might offer an obstruction to the free circulation.

Thrombosis is the formation of a clot during life in the interior of a vessel or in the heart. The clot itself is called a thrombus, and it may be a primary affection or secondary to phlebitis.

The **causes** are certain conditions which tend to slow the current of blood, associated with some abnormal condition of the endothelial coat. Varicose veins, atheroma of the vessels, ligature, or occlusion of the artery from external pressure are etiological factors concerned in the formation of thrombi.

Besides these special diseases and conditions concerned in the etiology of thrombosis, an altered quality of the blood may have a tendency to cause its coagulation. This is seen in such diseases as septicæmia, gout, rheumatism, and syphilis. The change in the endothelial membrane lining an aneurysmal sac is also a cause for the formation of a thrombus. During an attack of continued fever a thrombus may form in consequence of heart-weakness. This is observed in cases of severe surgical shock when the heart becomes so feeble that the blood coagulates. The thrombosed vein itself is probably injured at the time, which explains the formation of the clot in an otherwise healthy vein. Most important of all causes pertaining to the formation of a thrombus is the abnormal condition of the tunica intima. The integrity of the internal coat may be altered by traumatism, by pressure-effects, by infective inflammation, by the presence of parasites, by diseases of the coats of the vessels, and finally by the entrance of foreign bodies into the lumen of the vein, among which may be mentioned calcareous deposits, clots, or foreign bodies purposely introduced, as horsehair, tincture of iron, and metallic wire.

There should be a clear understanding of the difference between a post-mortem coagulum and one that is ante-mortem. The former occupies only part of the lumen of the vessel, is not adherent to the tunica intima, extends into the collateral branches, and is reddish-brown in color. The ante-mortem clot occupies the entire lumen of the vessel, tapers toward the heart, is whitish in color and soft in the interior, and may be adherent to the walls of the vessel.

Thrombi may be divided into two different varieties, and classified according to the infective or non-infective character of the thrombus. The non-infective variety forms generally in a vein in which from some cause the rapidity of the current of the blood is very much lessened. This thrombus generally begins in a pocket behind the valves, and consists of fibrin and white blood-corpuscles. The thrombus grows larger and larger until it fills up the lumen of the vein. The thrombus is at first white in color and solid in consistence. When the blood ceases to flow in the vein on account of mechanical obstruction due to the presence of the clot which fills up the entire lumen of the vessel, the blood begins to coagulate in the vicinity of the primary thrombus, so that often the secondary thrombus, which consists of coagulated blood, is redder and softer than the primary thrombus, and fills up a larger part of the vessel than the primary thrombus itself.

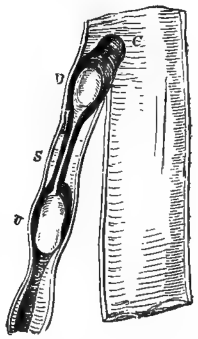
The *infective* thrombus forms in the same places as the non-infective

variety. It, however, contains in the clot bacteria, which produce a liquefaction and a metamorphosis of the thrombus into a substance which resembles pus. This liquefied mass enters the circulation and gives rise to the formation of emboli in other organs. The presence of an embolus in an organ checks more or less the rapidity of the blood-stream, and shuts off a certain amount of blood from the tissues supplied ordinarily by the embolized artery. The necrosis and putrefaction now extend over the whole region which was formerly nourished by the artery. Instead of a small area of necrosis, as is seen in miliary abscesses, extensive necrosis takes place. In the periphery of the necrosed tissue there is found a zone of purulent infiltration, and later a zone of pus, and thus metastatic abscesses are formed.

A *thrombus* may undergo central absorption and disappear, or it may undergo organization, or it may become absorbed in the periphery and then form what is known as the "filum terminale." In this form emboli seldom follow, since the clot is held *in sitû* by its ramification into the small branches. A thrombus may become liquefied and thus disappear, or it may even undergo suppuration.

The **signs and symptoms** of thrombus are severe and sudden pain in the affected part, which is greatly increased by any attempts to move the limb; the presence of a well-marked induration following the course of the vessel; œdema of the extremity below the thrombus; redness and swelling of the integument over the site of the thrombus; elevation of temperature; rapid pulse; frequent respiration; and all the manifestations of a general septic infection. The œdema at times is so tense as to prevent pitting upon pressure, and eventually may give rise to a condition known as "elephantiasis."

FIG. 373.



A thrombus in the saphenous vein, showing the projection of the conical end of the thrombus into the femoral vessel: *S*, saphenous vein; *T*, thrombus; *C*, conical end projecting into femoral vein. At *v*, *v*, opposite the valves, the thrombus is softened (Virchow).

The **treatment** of thrombosis must be directed to the measures necessary to prevent sudden death from a detached embolus, and also to the restoration of the function of the part.

Rest is an essential measure, to be rigidly insisted upon from the beginning of the attack until the clot is absorbed or becomes firmly adherent to the interior of the vein. Massage should be avoided, lest the clot be disintegrated and an embolus be swept into the circulation, causing softening, gangrene, or death according to the part in which it is lodged and the size of the vessel. The position of the part should be such as to favor venous circulation. Blisters should never be applied to the œdematous limb, and depletion should not be employed.

Embolism is the occlusion of a vessel by a fibrinous coagulum detached from a thrombus, by calcareous deposits washed off from an atheromatous ulcer, by fat, by air, or by shreds from a malignant neoplasm encroaching upon the lumen of a vein.

The word "embolism" is derived from the Greek word ἔμβολον, meaning a plug. An embolus (Plate H.) formed in any of the above ways is not found at the place where the coagulum originated. It is found at the spot where it has been carried by the blood-

stream, from vegetations on the valves of the left ventricle of the heart or detached from a thrombus, or from the laminæ in the sac of an aneurysm, or from a wound or malignant tumor growing into the vein. The presence of an embolus causes disturbance in the nutrition of the part supplied by the vessel thus occluded. Local gangrene may result in consequence of the lodgement of the embolus. In some cases only a temporary disturbance occurs, as in the case of an otherwise healthy individual with good circulation, since the collateral supply will afford sufficient nutrition to the affected part. Aneurysm may also result from the presence of an embolus. If the embolus affects one of the large branches of the pulmonary arteries or the middle cerebral artery, instant death is likely to occur.

The **signs and symptoms** of embolism consist of sudden sharp pain transmitted along the course of the artery, and also located in the parts which were formerly supplied by the obstructed vessel; numbness and tenderness in the surrounding parts, with coldness and pallor of the skin in the vicinity of the lesion. If a thrombus is present, capillary stasis occurs at the situation of the wound, and œdema below the wound, which appears dry, puffed, and unnatural. Suppuration is suddenly checked, and the granulations look flabby and are bathed with a sanious serous fluid. Irregular chills, fever of an intermittent type, rapid pulse, dry tongue, diaphoresis, and thirst are present, and occasionally delirium soon supervenes. Embolism can also occur without any open wound from a thrombus from which the embolus is derived.

The **treatment** of embolism, in case the lesion is in one of the extremities, consists in encouraging venous circulation by elevation of the limb, the application of artificial warmth to the extremity, the administration of opium to relieve pain, and the use of a generous and nutritious diet with free stimulation. If gangrene has set in, antiseptic poultices can be applied until the line of demarcation has formed, after which amputation should be performed. The writer once amputated the thigh for embolism of the popliteal artery. The embolus came from vegetations upon the valves of the heart, the result of an attack of acute articular rheumatism in early life, and the embolus occurred during convalescence from an attack of lobar pneumonia.

Varices or Varicose Veins.—Varices are elongated, dilated, tortuous, and thickened veins. The term "varices" is restricted to the veins of the extremities, and notably the saphenous and its branches. The same pathological condition when referred to the spermatic veins is called *varicocele,* and to the hemorrhoidal system *piles* or *hemorrhoids.*

In this connection the subject of varicose veins of the extremities only will be considered. The disease begins by a gradual dilatation of the vein, the walls of which soon become thickened by inflammatory exudation. The course of the vein is tortuous, and knobs appear at varying distances along its length. The endothelial lining membrane soon becomes altered, and the valves, on account of the dilatation of the veins, are unable to support the column of blood. The absence of this support afforded by the valves causes the vein to become dilated in segments, and pouches are thus formed along its course. The middle and external coats also undergo changes by a proliferation of connective-tissue cells and by an exudation of inflammatory products. Occasionally

the external coat becomes very thin and separates in certain segments, so that the internal coat protrudes through like an aneurysmal hernia. This protrusion may become pear-shaped with a distinct pedicle. The small tumor is the result of the protrusion of the internal coat with the blood, forming a pouch or pocket. If the varices occur in the small venous radicles as they arise from the capillaries, the varicosity is like a fine capillary injection and has an arborescent appearance. If the larger and superficial veins are the seat of the varices, the vessels appear above the surface of the skin, and the blood can be readily felt in the dilated thin, knotty, and tortuous channels. If the varicose veins do not stand out above the level of the skin, they are imbedded in œdematous tissue, which is caused by a passive exudation into the surrounding cellular tissue. This variety of œdema, also called by Liston the "solid œdema," differs from the ordinary œdema, in which some mechanical obstruction only is offered to the free return of the venous blood. In the former kind of œdema the limb does not pit on pressure and the parts are glazed and tense. Upon their surface a most intractable eczema often develops, followed by the formation of varicose ulcers, which give rise to alarming hemorrhage if rupture of the walls of the vein occurs or if ulceration into the lumen of the vessel takes place. Thrombi form in the veins in consequence of the altered condition of the endothelial lining membrane, and also on account of the irregular pouches. These clots often break down and form abscesses, as in suppurative thrombo-phlebitis, or the clots may undergo organization and occlude the lumen of the vessel, as in plastic thrombo-phlebitis. This latter process may effect a radical cure. The thrombi, instead of breaking down or undergoing organization, may shrink, and laminæ of fibrin be deposited upon them, and the lumen of the vein become occluded.

In addition to the fibrin, phosphate of calcium and the sulphates of calcium and potassium are deposited, so that typical calculi are formed, to which the name of "vein-stones" or "phleboliths" has been applied. In all cases of varicose veins Gay has pointed out the clinical fact that "the general circulation has been subject to a very considerable and long-standing embarrassment."

The causes of varices are predisposing and exciting.

Among the *predisposing* causes sex may be mentioned, since the disease is most frequently seen in the female, especially in consequence of enlargement of the uterus. Age is also a predisposing cause, since the tendency toward varicose enlargement increases as age advances. Obstructions in the form of tight-lacing and the use of garters are predisposing causes. Certain occupations tend to the development of varices, since it has been demonstrated that persons who are habitually required to stand are more frequently the victims of the disease.

Among the *exciting* causes may be cited all varieties of abdominal and pelvic tumors, among which may be mentioned the gravid uterus, neoplasms, and fecal impaction. These tumors by their pressure-effects cause a retardation, and in some cases even an arrest, of the flow of the venous blood toward the heart. The pressure is exercised generally upon the two iliac veins, in which case the varicosities appear in the two limbs simultaneously.

Diseases of the heart and lungs are exciting causes to develop vari-

cose veins. A feeble heart will not force satisfactorily the blood back to the heart, and as a result the current becomes nearly arrested. In affections of the heart accompanied by dropsy the serous effusion in the peritoneal cavity causes pressure upon the abdominal veins.

The **signs and symptoms** of varicose veins consist of the presence of elongated, tortuous, knotty veins, the size of which is materially affected by the position which the patient assumes; the formation of ulcers secondary to eczema and œdema; the occasional presence of hard, stony concretions in the veins of the leg; and the presence of thin skin over these blue tortuous vessels.

A varix of the femoral vein must be differentiated from a femoral hernia. Both of these tumors present at the femoral ring, and both disappear when the patient assumes the recumbent position. In the varix the tumor returns as soon as the patient takes the upright position or coughs while pressure is made over the saphenous opening. In femoral hernia the tumor does not descend as long as pressure is made over the opening.

The **treatment** of varicose veins may be palliative or radical.

The *palliative* treatment consists of attention to the general health and to measures directed to relieving as far as possible the local causes. The bowels should be regulated, the normal functions of the liver maintained, and the action of the heart and lungs restrained within normal limits. Rest in the recumbent position when practicable, and horizontal position of the limb when the patient is in the sitting posture, should be prescribed.

The local measures consist in the application of a properly-fitting elastic stocking to give support to the veins. The uniform pressure of the stocking has a tendency to drive the blood from the superficial veins into the deeper ones, which are not so frequently affected with varicosity. The stocking should be made to exercise just enough pressure to afford support to the vessels, and to accomplish this object it becomes necessary to have the limb accurately measured. The stocking should extend from the foot to the knee, and if the long saphenous vein is involved the stocking must extend above the knee to the groin and be divided into two separate segments.

If varicose ulcers are present, they should be treated by horizontal posture of the limb or rest in bed. Over the ulcer iodoform, bismuth, oxide of zinc, or aristol can be dusted, and Martin's elastic bandage applied. A few days before using these powders the ulcer should be freely incised in order to remove the callous rim of indurated tissue which prevents the ingress of blood to the floor of the ulcer. The employment of powders should be discontinued after a few days and balsam of Peru or stimulating ointments substituted.

The *radical* treatment has for its object the complete obliteration of the varicose veins. With this object in view many operations have been devised.

Mayo suggested the use of caustics in the form of Vienna paste, which is made of 4 parts of potassa fusa and 4 parts of quicklime with spirits of wine. This paste is applied over the vein while the surrounding skin is protected by a ring of adhesive plaster. The object is to cause a slough in the vein, and when several of these rings are applied

along the track of the vein the channel becomes obliterated. The caustic paste is left on for about twenty-four hours. The patient should be confined to the bed during the treatment.

Lee suggested acupressure, by using several pins which are passed beneath the vein about an inch apart, and then silk twisted around them in the form of the figure 8, or by the use of a small elastic band. He also suggested excision of segments of the vein between the pins, especially during an attack of acute suppurative phlebitis.

Sir W. Ferguson modified Lee's operation by dividing the skin to allow the silk to sink down in the groove and thus come directly in contact with the wall of the vessel.

Madelung allowed the patient's leg to hang down from the operating table, having previously tied a rubber tubing around the thigh tightly enough to produce obstruction to the venous return, but not tightly enough to obstruct the arterial flow. A double ligature is placed above and below, and an incision through the skin is made longitudinally down the whole length of the vein, which is dissected out from above downward and the branches tied as the dissection proceeds.

Mr. Davies Colley advised complete excision of the vein. This operation was originally recommended by Celsus, but was revived and put into practice by Mr. Marshall, who, after marking out the course of the vein, applies an Esmarch's bandage and dissects out the segment of the vein between two pins placed above and below.

Porta recommends injections of chloral into the vein, and Brodie suggested the subcutaneous division of the veins.

Isaac suggested sulphate of iron (1 part of the preparation to 20 or 30 of water). If the iron is used any stronger than this, it excites too violent an inflammation.

Mr. Bryant suggested the tannin injection into the perivascular tissue.

Herepath practised the operation of enlarging the saphenous opening by the use of a tenotome for the purpose of removing a cause of mechanical obstruction.

Velpeau, following Davat, employed a metal pin which was passed under the vein and upon which a twisted suture was applied.

Fricke pierced or transfixed the vein with the needle.

Vogt highly extols the hypodermatic injection of ergotin into the perivascular connective tissue. The ergotin should be freshly prepared in distilled water, to which a small quantity of carbolic acid can be added to prevent decomposition. The punctures made by the needle are hermetically sealed by iodoform and styptic collodion. The vein should never be wounded.

Lange suggests in the same manner pure carbolic acid or absolute alcohol, and Bozeman introduced the button-suture.

Tillmanns highly praises the employment of ignipuncture of the varicose veins with the fine point of the needle of a Paquelin cautery. The punctures heal under a scab which eventually falls off. The use of iodoform and styptic collodion can be employed if the openings bleed.

Many other operations might be mentioned for the relief of varicose veins, but the list is sufficiently complete to illustrate the principles upon which all the operations are based.

Phelps has suggested an antiseptic operation based upon the application of multiple ligatures to the internal saphenous vein. In Phelps's operation are embraced all the advantages of the other methods, and it seems destined to be the most valuable addition to the surgery of varicose veins. He restricts his operation to those cases in "which there is some direct purpose to accomplish," and which may be very well classified as follows:

1. Cases where this condition constitutes disability in physical examination, as for the admission to the army or navy or for appointment in a municipal department.
2. Cases where the size of the veins, the formation of venous tumor, or the attenuation of the coats or tegumentary coverings threatens hemorrhage.
3. Cases where chronic ulceration or eczema exists.
4. Cases where circulation has been so far impaired as to occasion swelling of the feet or loss of power in the limb.

In a published list of nearly two hundred cases, to which many since have been added, Phelps has performed this operation with no death and no septic infection, and in all cases a most satisfactory result as far as the immediate effects of the operation are concerned, and in only a few cases was a secondary operation required. Intractable eczema disappeared, varicose ulcers healed, œdema subsided, natural circulation was restored, and over a period of three years at least the cure appeared permanent.

Phelps's operation is based upon the principle of "entire occlusion of the whole length of the affected vein." He applies numerous ligatures to the vein, in some cases as many as seventy or eighty. The intervals should not be greater than from one to two inches. If a varicose ulcer is present, the Paquelin cautery should be employed in order to obviate the dangers of sepsis and also to stimulate fresh and healthy granulations to cure the ulcer. The application of rigid asepsis is necessary to prevent suppuration. The entire limb should be rendered thoroughly aseptic before beginning the operation. The material used for ligation is catgut, and special pains should be taken to ensure its perfect asepticity.

The ligation is best performed by the use of "a flattened straight needle sufficiently broadened toward the point to enclose an eye for the catgut immediately behind the vein, and the needle unthreaded and withdrawn."

"The needle is then carried immediately in front of the vein through the openings which it has previously made, and the end of the ligature caught up and brought back. The vein is thus subcutaneously included in the ligature, which is then tied and cut short, and, if the catgut is fine enough, the knot pushed back beneath the skin. If, however, the vein is larger, and coarser catgut has to be used, no trouble results from leaving the knot in the orifice of the wound. It occasionally happens that a large anastomotic vein, passing vertically inward to the intermuscular vessels, will prevent occlusion of a superficial vein at a given point, leaving a globular varix. In that case it may be necessary to tie the anastomotic branch. This may be done in the manner devised by Dr. E. W. Clarke, house-surgeon at the New York Hospital, for approximating the fragments of a fractured patella. The ligature is carried deeply along one side of the vein; the needle is re-entered at the point

of exit, and with the ligature carried at right angles to the first line of puncture; it is then re-entered at the second point of exit, and carried at right angles to the second line of puncture; it is again re-entered at the last point of exit, and brought out at the original point of entrance, thus surrounding the vein. After the dressings have been applied the limb should be placed upon a posterior splint and the patient kept in bed for about ten days or two weeks, after which he should wear a roller bandage for two months."

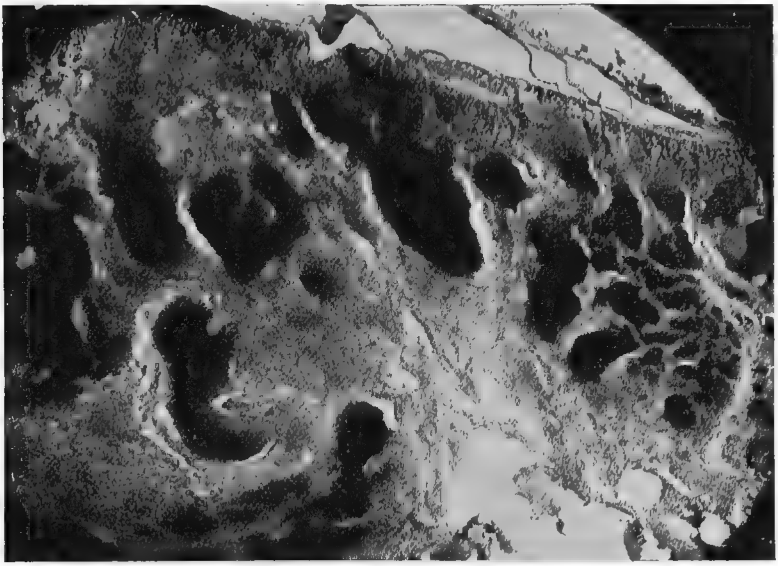
NÆVUS, or mother's mark, is a tumor composed of dilated capillaries in the form of convolutions. The terms birth-mark, telangiectasis, and strawberry mark are synonymous. Nævi are situated in the corium and also in the subcutaneous tissues. They are congenital, and appear at birth in the form of a bright red spot just under the epithelial layer of the skin. If they are situated superficially, they involve the capillary network only, but if situated deeply, they may involve the veins and are then imbedded in the subcutaneous tissue. In the former case the appearance of the patch is bright red; in the latter case it is bluish, and is sometimes designated as a port-wine stain. The patches vary in size from the point of a pin to an area which would not be covered by the hand. They are observed upon the trunk, face, scalp, and extremities. They present often an unsightly appearance, but seldom give rise to pain. They may cause, if injured, troublesome and in some cases alarming hemorrhage. They ulcerate occasionally, in which case fatal hemorrhage may occur.

The nævus is composed of a network of newly-formed and old capillaries, the walls of which are dilated so as to form pouches. The tumor seldom rises above the level of the true skin. Nævi are found also upon mucous surfaces, in glands like the mammary, also in the brain and in the bones. Nævi are occasionally found imbedded in hypertrophied and pigmented skin, and hair is found growing from the surface.

In the *cavernous angioma* (Fig. 374) there are no separate vessels which are distinct, but the blood is contained in spaces which are lined by endothelium. The anatomical arrangement is similar to that of the cavernous portion of the penis in which the function of erectility is present. The tumor itself is partitioned off by connective-tissue septa, and into these spaces fluid blood flows. The origin of these congenital vascular tumors is still *sub judice*. Rokitansky and the followers of his school of pathology believe that these cavernous spaces are formed in the fœtus out of the surrounding connective tissue, and that later the capillaries open into them and supply the blood to fill the sinuses. Other pathologists hold the opinion, which is now accepted, that the existence of these congenital vascular tumors is due to a dilatation of the capillaries, the walls of which, lying adjacent to each other, eventually become absorbed and spaces are thus formed. Cavernous angiomata are formed in the subcutaneous tissue, in organs like the liver, kidney, spleen, brain, uterus, and also in bone and in cavities like the orbit. These tumors pulsate and grow much larger than the capillary nævus. If pressure is applied to them, they can be made to partially disappear, but as soon as the pressure is remitted they immediately reappear. The histological formation is very similar to that of true carcinoma, with the exception that the spaces are filled with fluid blood instead of epithelial

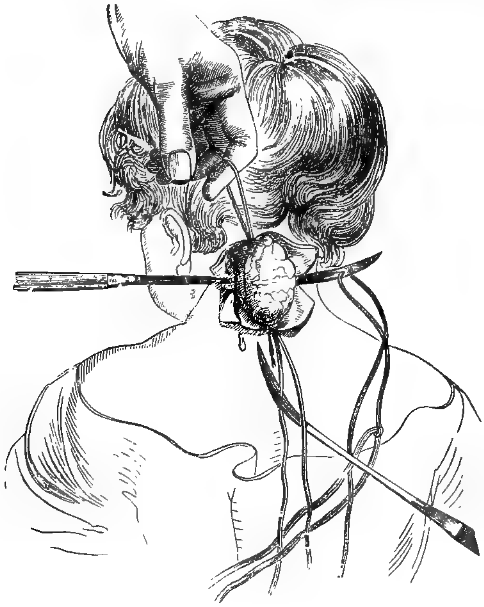
cells. The presence of a cavernous angioma constantly menaces the life of the patient, since a scratch from even a pin may induce a fatal hem-

Fig. 374.



Section of cavernous angioma involving the skin.

Fig. 375.



Nævus: application of quadruple ligature (Liston).

orrhage. Cavernous angiomata have no tendency to contract or disap-

pear, but rather a tendency to grow until they attain considerable size and cover a large area of space.

The treatment of nævus, whether of the capillary or the venous variety, and of the cavernous angioma, is indicated not only for cosmetic effects, but also for the future safety of the patient. The operations which have been devised for the relief of these tumors are multifarious, and embrace almost every form, from the puncture of a needle to a most formidable surgical procedure. In the small capillary nævi injections of sulphate of iron can be employed, provided the nævus is not situated upon the face, neck, or scalp. In these situations the danger of the formation of a thrombus is very great. An embolus might become detached from the thrombus which may be swept into the circulation and cause instant death. The literature of surgery contains the reports of many deaths from this cause. If the nævi are upon the trunk or upon the extremities, the injection method can be safely employed. Vaccination has been employed in small nævi, but the results are not such as to recommend this plan of treatment.

The use of the galvano-cautery or the thermo-cautery, or of electrolysis, in nævi situated upon the face, neck, or scalp is to be highly recommended. If the nævus is of moderate size, it can be transfixed under its base by two needles and a ligature passed around under the pins so as to cause strangulation of the entire mass (Fig. 375).

If the nævus is large, it can be tied off by ligatures after the manner of ligating the pedicle in the operation of ovariotomy. Sir Wm. Fergusson devised an operation for strangulating the nævus "by passing a double thread beneath the growth and dividing the loop left at the hole of exit. Thread the needle with one of these ends and pass it under the growth at right angles to the double thread. The needle is now unthreaded, and the

Fig. 376.

Fergusson's ligature for nævus, including skin.

Fig. 377.

Sarcoma growing through pulmonary vein into left ventricle of heart.

other divided and put in the eye, that it may be withdrawn with the needle" (Fig. 376).

Excision can be employed when the nævus is situated in such a place that an alarming hemorrhage can be controlled and aseptic healing can be secured. The use of setons and of coagulating injections is attended with danger, owing to the risks of suppuration, hemorrhage, and embolism. The application of fuming nitric acid to a nævus of any size has been abandoned. The injection of 95 per cent. of carbolic acid in glycerin has been highly recommended. Injections of a few minims are made around the periphery of the tumor in several places.

In excision of large-sized cavernous angiomata the base can be transfixed before it is excised. In case the hemorrhage becomes alarming Paquelin's cautery can be used. If a vessel can be found entering the tumor, it should be ligated before attempting complete enucleation by excision.

Tumors of veins are not infrequent. A neoplasm consisting of hyperplasia of the middle coat has been observed in the ulnar and saphenous veins, and sarcoma has been seen in the vena cava. The writer has recently observed a case of sarcoma of the lung in which the mass grew in the shape of a mushroom through the pulmonary vein into the cavity of the heart and caused death (Fig. 377). The coats of the veins are very often the seat of metastatic malignant growths. The tumors ulcerate through the thin wall of the vein, and the cells are thus swept into the venous channel, and set up metastatic malignant foci in other and distant parts of the body.

PLATE III.

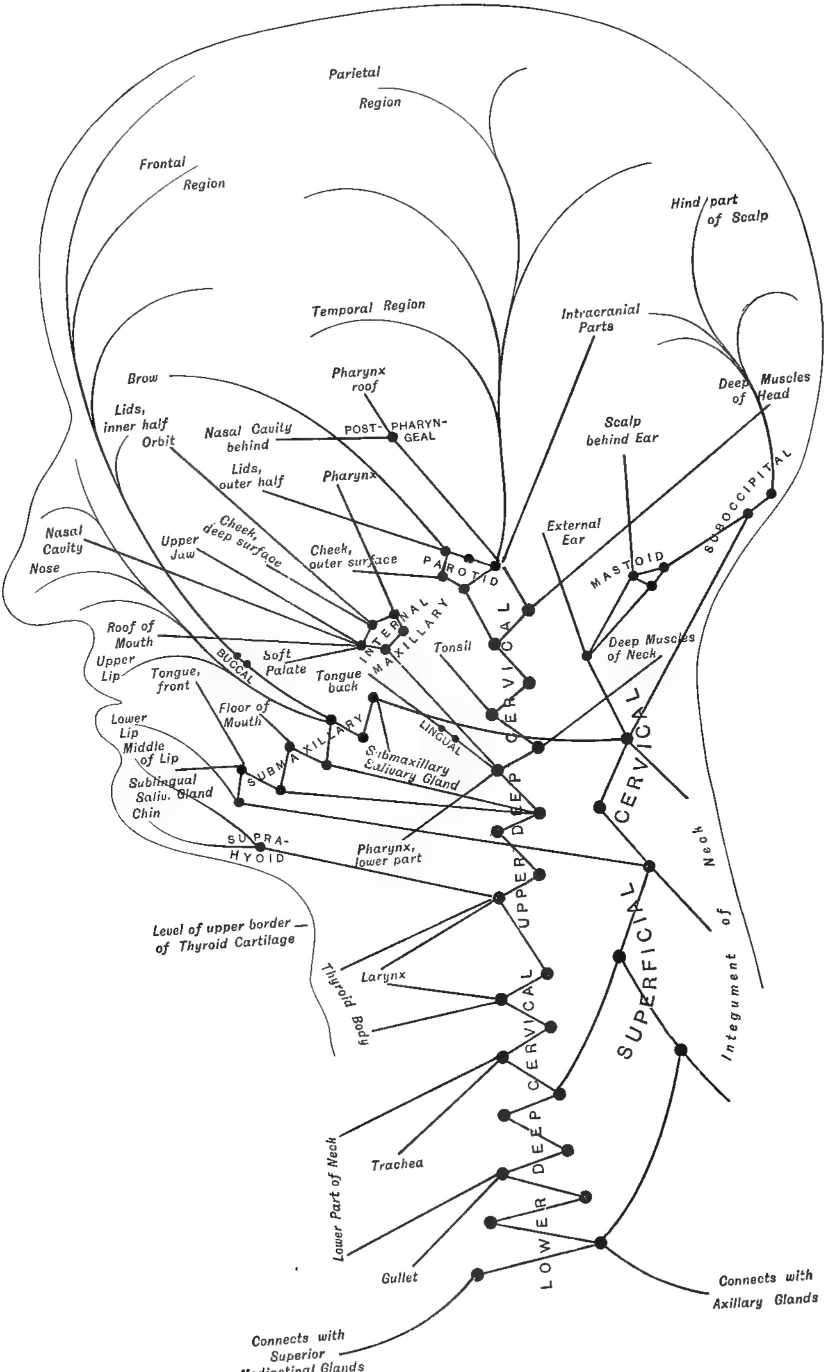


Diagram of the lymphatic glands and vessels of head and neck, showing the areas which are drained into each group of glands—deep structures in red, superficial in brown.

SURGERY OF THE LYMPHATIC SYSTEM

By FREDERIC HENRY GERRISH, A.M., M.D.

At the beginning of his justly-celebrated Gulstonian Lectures in 1879 Curnow made this statement: "The lymphatic system has had but little notice taken of it since the time of the Hunters and Monro; and from the extravagant notoriety which it then attained it quickly passed into an opposite extreme of general neglect, from which it is now emerging."

In the sixteen years since these words were spoken surgery has made a wonderful advance, thanks mainly to the genius of Lister and his disciples, and the new science of bacteriology has thrown a bright light into many dark places. The lymphatic system has had its share of the benefits coming from these sources; and, while there is yet much to learn, we have the satisfaction of being far better equipped than our predecessors, both for diagnosis and for treatment. We appreciate more fully the importance of the rôle played by the lymphatic vessels and glands,[1] particularly in their relation to the dissemination of cancer and tuberculosis; we perceive that the diffused and ill-defined adenoid structures, which were largely ignored by the anatomists, are often the seat of grave diseases; we attach more practical significance to the almost infinitely minute and indescribably irregular spaces of the connective tissue in which the vessels have their origin; and the recent discovery that leucocytes (lymph-corpuscles and colorless blood-corpuscles), instead of being of a single kind, are of five or more varieties, justifies the hope that certain obscure conditions of the greatest seriousness will soon be so illumined that their true character will be made apparent, their early recognition become easily possible, and thus a foundation laid for rational therapeusis and rapid cure.

Lymphatic structures of some kind are found almost everywhere in the body, and, consequently, are involved to some extent in morbid processes, whatever their nature or situation. Frequent allusions, therefore, are made to these organs in other portions of this work, and some affections which are essentially lymphatic are very properly assigned to articles on regional surgery. This article is devoted to those diseases and injuries which affect the lymphatic system in general, and the greater part of those in which the implication of some particular portion of it constitutes the principal feature of the disorder.

It is of importance to the surgeon to know precisely the parts which

[1] The word "glands," as applied to the bodies which interrupt the lymph-stream at intervals, is objectionable, because these are not true secreting organs. The word "ganglion," used by the French, is preferable. "Node" is perhaps better still, and will be frequently employed in this article instead of "gland" where its use will not cause confusion.

contribute lymph to each particular group of nodes. This information, however, is not always presented in an intelligible manner in the works on anatomy, and consequently the accompanying diagrams have been devised in order to show at a glance the sources from which nodes accessible to the surgeon's knife derive their lymph. Thus, when a single node or a colony is invaded by disease, attention is immediately directed to the region in which must be sought the causative irritation or the lesion by which toxic material has been introduced. In using these diagrams it should be remembered that at the margins of a peripheral area there are frequent lymphatic anastomoses with surrounding areas, that the nodes of each group communicate freely with each other, and that every colony is connected more or less intimately with its neighbors.

Tuberculosis and Scrofula.

In view of the importance of the rôle assigned to tuberculosis and scrofula in the pathology of lymphatic diseases, it is desirable to consider them in a general way at this point before taking up the specific affections of the absorbent system.

As the intimate relationship of tuberculosis and scrofula has always been recognized, they are more conveniently and profitably studied together than separately, and hence are placed in the same section.

For a very long time the word "tuberculosis" has suggested to the medical mind a tolerably well-defined idea. It has, it is true, been variously applied by pathologists, but to the clinician it has meant a disease of which the most prominent and characteristic feature is the development, in one or several of many parts of the body, of microscopic nodular masses which have a disposition to multiply with more or less rapidity and to take on various degenerative processes, in the course of which the tissues occupied are destroyed, and often the life of the patient imperilled or lost.

These minute bodies are called "tubercles," from their shape, and they give the disease its name.

Tubercles vary greatly in the materials which enter into their composition and in the manner in which these are arranged. A tubercle may be merely a little cluster of leucocytes or of epithelioid cells, or a collection of these two kinds of corpuscles in varying proportions, either with or without a reticulum, or an association of some of each with one or more giant-cells. When this last arrangement obtains, the parts are generally disposed as follows: In the centre is the giant-cell, next is a zone of epithelioid cells, and outside of this a zone of leucocytes, the whole structure sustained by a delicate network of fibres. This is regarded as the most complete and typical form of tubercle. Both before and after this stage there are periods when the tubercle does not conform to the type, for time is required for development, and also for the accomplishment of the degenerative changes to which tubercle is subject. The giant-cell is not always present, though formerly it was supposed to be essential. The fact is, that there is no distinctive anatomical element in tubercle; and, besides this, giant-cells are found elsewhere than in tubercle. The method of the formation of these cells is still in dispute.

Fig. 1

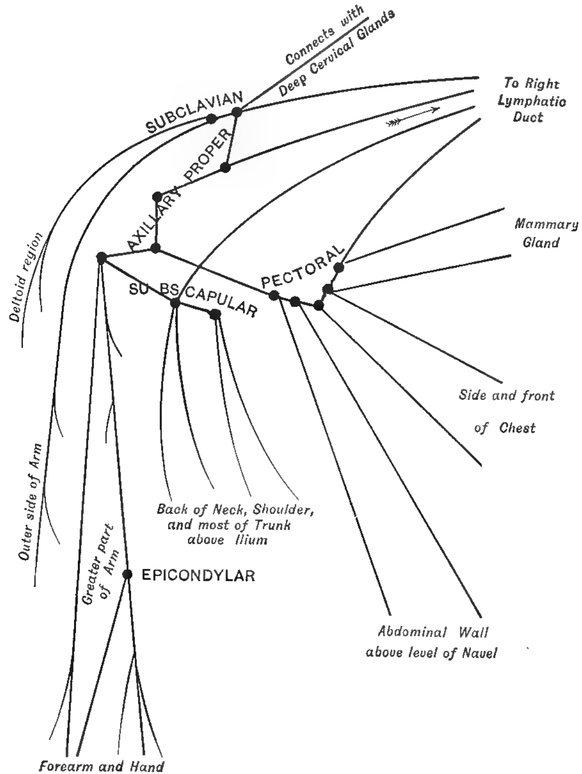


Fig. 2.

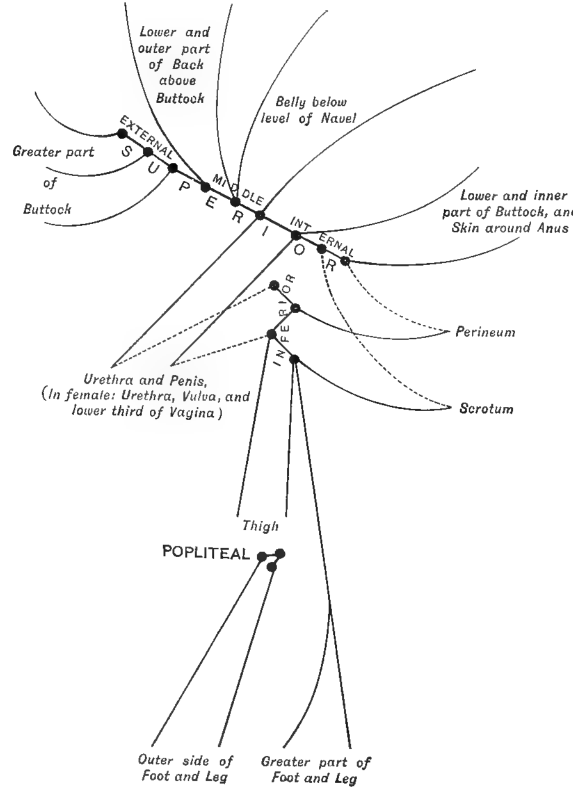


FIG. 1.—Diagram of the axillary glands and their superficial tributaries (right side), showing areas drained by each sub-group. Deep structures in red, superficial in brown.

FIG. 2.—Diagram of the superficial glands of the groin (right side) and their tributaries, showing areas drained by each sub-group. Deep structures in red, superficial in brown; dotted lines indicate frequent variations.

Tubercle is demonstrably an inflammatory product: it is not a neoplasm in the proper and accepted sense of that word. The inflammatory process which precedes and results in the formation of tubercle is excited by certain bacteria, called bacilli tuberculosis, partly by the mechanical effects of the bodies of the micro-organisms, but much more by the action of certain products of their vital functions, either alkaloidal substances (toxins) or albuminoids (toxalbumins or toxalbumoses).

The bacilli gain admission to the body in various ways: they are inhaled in the air which is breathed, they are ingested with food, they enter through breaches in the surface of the skin and mucous membranes, they may even pass through the unbroken integuments. They are readily carried in the blood- and lymph-vessels, the latter being the channels by which they are conveyed in those tuberculous diseases which are surgical. As their numbers multiply with great rapidity in favoring circumstances, the inflammation which they excite may extend itself with corresponding speed, either upon the surface or in the tissue which first received the germs; or the bacilli may be carried from the point of original infection through the vessels to a distant point, and there establish a new focus of disease. Thus, it is possible for a tuberculous deposit at any point to disseminate the disease to any other part in which the bacilli can breed. Generally, however, one region or one set of organs alone will be involved, though cases occur in which many tissues and different organs are affected successively, and there may be a sudden and simultaneous explosion, as it were, of tuberculosis in many parts, the material being furnished by a single focus.

After the death of the bacilli certain chemical constituents are set free from their bodies, and in some mysterious way attract to their vicinity large numbers of leucocytes from the neighboring vessels. The bacteria also excite great reproductive activity in the connective tissue, and by these means suitable material for manufacturing the tubercular deposit is at hand.

The formation of tubercles is followed by such changes in the immediate region as result in its non-vascularity. Tubercles may remain quiescent for a long time, but not indefinitely. Sooner or later they experience destructive changes, the commonest being caseation, which is in large part a fatty degeneration. The cheesy material either becomes a fibrous or hyaline mass, or is calcified, or breaks down and softens, abscess being a frequent termination.

It must not be expected that every case of tuberculosis will run a similar course: there are many variations to be observed, both from the pathological and the clinical point of view. The duration of the disease ranges between a few months and many years; the destruction of tissue may be insignificant or enormous; the effect on the general health may be inappreciable or annihilating.

An eminent surgeon has said that lymphatic tissue "forms as much the basis of tubercle as epithelium does of epithelioma." Though this statement of the case is too broad to win entire assent, it comes very near the truth if limited to those lymphatic diseases in which surgery is most concerned. The lymphatic system furnishes great facilities for the extension of this disease. The glands entangle and detain the bacilli in their meshes, affording the best possible conditions for breeding the mor-

bid process which they are capable of awakening, and the efferent vessels are constantly ready to bear nomadic bacteria to other fields in which they may propagate.

There are many persons who have a predisposition to tuberculous disease; that is to say, there is in them some subtle defect of constitution which prevents their resisting successfully the attacks of the bacillus tuberculosis. Their bodies are a more suitable soil for the growth of this vegetable organism than is afforded by those of most other people. This predisposition is undoubtedly hereditary in many, if not most, who have it. Though one of the parents of such a person has probably been tuberculous, this is not necessarily the case: syphilis, and perhaps other diseases which have a debilitating effect upon the constitution of a parent, may produce in the child a condition which is almost an urgent invitation to the bacillus.

The **treatment** of tuberculosis must be varied according to the needs of each particular case. But there is an implication in what has just been said that one part—and often the most important—of a surgeon's duty to a tuberculous patient is to combat the tendency of the general system to yield to the incursions of the bacillus. If this task is left undone or underdone, his efforts in other directions will probably prove unavailing.

"Scrofula" is a term much more restricted in its application to-day than formerly; indeed, the history of the subject shows that its domain has been gradually encroached upon for generations, until it now occupies but a small part of its once extensive territory. To how much of its present field it is entitled it is the purpose of the remainder of this section briefly to discuss.

In illustration of the contraction of the province of scrofula it is only necessary to mention that it has claimed as its own, at one or another time, cancer, hereditary syphilis, chronic hydrocephalus, diabetes, worms, lice, and rickets. The tendency to curtailment is still manifest: it is far less common now-a-days than it was twenty-five years ago to hear certain chronic bone-and-joint affections called scrofulous; and lymph-gland enlargement, always the most conspicuous and characteristic tenant of the once great field, is left practically alone, where it anciently had a host of companions. Delafield and Prudden, in the article in their work on pathology which treats of inflammation of lymph-nodes with cheesy degeneration, after discussing the appearances observed at the several stages of the affection, and stating that "it is most apt to occur in badly-nourished young persons, who, in addition to the lesion of the lymph-nodes, are very liable to suffer from chronic inflammations" of specified structures, remark: "This general condition is known as scrofula, and the lesion of the nodes is sometimes called scrofulous inflammation. It is not infrequently associated with tubercular inflammation of the nodes, either as an independent lesion or as a part of a general tuberculosis, and by some writers tuberculous and scrofulous inflammations of the lymph-nodes are considered to be identical. In a considerable proportion of cases, however, of so-called scrofulous inflammation of the lymph-nodes there is no formation of tubercle-tissue, and we find no tubercle bacilli; so that we must consider this class of cases as simply inflamma-

tory, with a tendency to cheesy degeneration." This is all the consideration given to scrofula in that admirable modern work. Still more significant of the existing situation respecting scrofula is the growing disposition to detract from its dignity by denying it a right which, until recently, has been unquestioned. While some lexicographers and other writers still call it a "disease," others define it as a "condition," and still others as a "tendency." The *National Medical Dictionary* says that it is—"1. A constitutional condition which favors the development of tuberculosis; usually inherited, but may be acquired. 2. Tuberculous gland-affections." Virchow says that it consists in "a greater vulnerability of parts and a greater pertinacity of disturbances" than is normal. Butlin says: "The essence of the disease lies rather in several tendencies or predispositions than in any clearly-defined conditions." And Treves declares it to be "a tendency in the individual to inflammations of a peculiar type"—"a diathesis."

Scrofula, therefore, is entitled to be called a disease, even by those who still consider it such, only in the case of a fractional part of the inflammations of lymph-glands. But, in view of the facts that before removal of the glands in question it is impossible to distinguish those in which there is an association of scrofula and tubercle from those in which there is not; that all of them until a few years ago were held to be scrofulous, and the great majority now are known to be tuberculous; that bacteriology is still in its infancy, and admittedly far from perfect, though gaining ground with marvellous rapidity,—it is reasonable to expect with confidence that the dwindling of the domain of scrofula which has been going on for so long a time will continue, and that our knowledge will increase within a few years to such an extent that scrofula will be crowded off from its only remaining bit of territory, and thereafter be merely an historic memory. Indeed, the word might with advantage be discarded immediately, for it has outlived its usefulness. Its meaning to-day is altogether too confused and vague to be valuable. When our predecessors used it a concrete idea was suggested: they had in mind a disease of which many examples were easily to be seen. But if, when we speak of scrofula, we mean merely a tendency to a kind of inflammation, where can we find our illustrations? How can we demonstrate the tendency to tuberculosis until there have been actual manifestations of the disease—until, in fact, the tendency has ceased to be such by developing into a positive pathological state? We should, and do, call such a patient tuberculous, not scrofulous. Furthermore, when we consider that fully 60 per cent. of us have in the present, or have had in the past, real tuberculosis, as shown by critical post-mortem examinations of multitudes in all respects like ourselves, it is rendered probable that the tendency to tuberculosis is, in some degree, well-nigh universal; and yet it is unlikely that any one of the authors quoted would care to stand by this definition of scrofula if its application were carried to this logical extremity. Scrofula, as the name of a disease, has doubtless served a useful purpose. But as the other diseases which were once thought to be exhibitions of scrofula have been ascertained to be nothing of the kind, so now its typical manifestation is found to be one expression of another disease, distinct and long recognized. There is nothing left for the word "scrofula" to do, and its retention in our living nomenclature

will conduce only to confusion of thought and consequent obstruction of progress.

Affections of the Lymphatic Vessels.

INFLAMMATION OF LYMPHATIC VESSELS.

Synonyms.—Lymphangitis (*lympha* = lymph + ἀγγεῖον = vessel), Lymphangeitis, Lymphangiitis, Lymphangioitis, Lymphatitis, Lymphitis, Angiolymphitis, Angioleucitis (ἀγγεῖον = vessel + λευκὸς = white), Angeioleucitis, Angiolymphitis.

The conventional division of this disease into idiopathic, traumatic, and septic seems at the present time not only unnecessary, but incorrect. Bacteriology has made it almost certain that whenever this inflammation depends upon injuries it is septic, and that no inflammation of lymphatic vessels occurs save through microbic agency. Thus, even if we are not prepared to declare dogmatically in every case exactly what micro-organism is concerned in the process, or in precisely what manner the bacteria have obtained admission to the channels and have been encouraged to undertake their peculiar task, we are justified in discarding the long-overworked adjective "idiopathic," the domain of which has been of late years so diminished by increase of knowledge that it seems destined soon to be altogether extinguished.

Lymphangitis is almost always a secondary process, depending in one way or another upon some traumatism. It is not necessary that there should be a veritable breach of surface through which toxic material is absorbed: septic matter sometimes passes through the uninjured integument. The inflammation is not in all cases awakened by the same kind of bacterium, and the microscopic appearances during and after the attack differ greatly. The entrance of any of the various micro-organisms capable of inducing inflammation in these structures probably occasions the formation of a thrombus. Generally, perhaps, pus-cells are found within the vessel-walls, the epithelium of which is either swollen or desquamated, and the lymph is thickened with clots of fibrin and epithelium which has been shed. Around the tube are leucocytes which have wandered from its lumen, and are now pus-corpuscles, with more or less exuded lymph. The circumjacent tissues are inflamed in all but the most trivial cases. When the inflammation is tubercular the bore of the vessel may be encroached upon, or even obliterated, by characteristic deposits and growths originating within the tube itself or in the surrounding parts. Complete resolution may take place, or, on the other hand, destruction of the vessel may occur from abscess, or its absolute occlusion ensue from hyperplastic changes. In most cases of lymphangitis there is some involvement of the related glands—a subject reserved for consideration later in this article.

It has been asserted that lymphangitis and erysipelas are identical, because streptococcus pyogenes is found in lymphatic abscesses. This view is strenuously combated, and the question still awaits settlement. It is interesting, however, to note the fact that erysipelas is essentially a lymphatic process.

In mild cases of lymphangitis there is a sensation of local irritation;

red lines are seen coursing from the periphery toward the centre, and these are felt to be hard, beaded cords. Later on, a blush diffuses from these lines over the adjacent surfaces and the receiving glands are inflamed. There is slight febrile movement.

All these symptoms are aggravated in severe cases. There is acute pain in all of the implicated tissues, the morbid process overflowing the nearest glands and extending through their efferents to more remote clusters of nodes. Fever is high, and œdema pronounced, sometimes constituting the chief danger. If the disease progresses still farther, abscesses form in the glands and areolar tissues, those in the latter situation being diffuse; there are rigors, excessive thirst, dryness of the tongue, vomiting, diffluent abscess in distant parts, restlessness, delirium, and, finally, death from the general septic poisoning. The method of termination in this disease depends upon the nature and quantity of the septic material, the general condition of the patient—especially as regards the integrity of the kidneys—and the promptness and propriety of the treatment.

When the superficial network of vessels alone is involved (reticular lymphangitis) there will be an absence of many of the above-mentioned symptoms; but the tubular is frequently associated with the reticular form. The classical symptoms of inflammation are present, the tenderness being exquisite and the swelling œdematous. Patches of variable size and shape mark the extent of the disease. In the so-called "wandering" variety, which usually is set up by a dissecting wound or by repeated contact with putrid matter, the patches succeed one another in an irregular course up the limb, each lasting a few days. It is considered less serious than the deeper tubular form of inflammation.

The deep vessels are sometimes independently inflamed. There are no discolorations of the surface unless the disease rises above the deep aponeurosis. Pain is lancinating, and there is great hardness of the part from the outset. Often there is deep suppuration.

All forms of lymphangitis may work backward; that is, from the centre to the periphery. The disease may run up on one set of vessels, implicating one gland or a group, and then extend downward on another set of vessels which empty into the same nodes.

In the local **treatment** a hot pack of a corrosive-sublimate solution (1 : 2000) is probably as valuable a topical application as can be made, but many other things are in high favor: hot fomentations, either of simple water or water impregnated with poppy-heads; equal parts of belladonna and glycerin; lotions of chloride of ammonium, laudanum, tincture of belladonna, and carbolic acid. The application of a blister completely around the limb above the affected area is advocated on the principle of demolishing houses to arrest a conflagration. Free incision is imperatively demanded whenever pus has formed, and even when its presence is strongly suspected. Systemic treatment must be conducted on general principles, the bowels being kept open, the kidneys never forgotten, anodynes used as needed, and supportives employed according to the extent of the vital debility. The coal-tar products, which are so fashionable as antipyretics, should be exhibited with caution, if at all, as their comforting effects are often more than offset by the depression which they cause.

WOUNDS OF LYMPHATIC VESSELS.

Severance of lymphatic vessels is inevitable in every incision, but harm comes of it very exceptionally. It is only when channels of large size are opened that lymphorrhœa or lymphorrhagia[1] follows, and neither of these difficulties is common. Fistula is more likely to follow the opening of a vessel by ulceration than to result from a cut. In either event the application of a little caustic and firm compression will almost always suffice to cure. These remarks are intended to apply only to injuries of healthy lymph-vessels, and not to those which are varicose or otherwise diseased.

The thoracic duct is so fortunately lodged that it is very seldom wounded. Such a lesion is the most serious that the lymphatic system can sustain. The contents of the duct escape into the surrounding parts —at some times entering the chest and constituting chylous hydrothorax, at others being poured into the abdominal cavity and causing chylous ascites. Inflammatory thickening of the mesentery has also been responsible for the same condition. The patient is to be kept perfectly quiet, and given only such an amount of food as will barely save him from actual starvation, in the hope that by keeping the duct as nearly as possible empty the accidental opening will close; but the prospect of success is not brilliant.

OCCLUSION OF LYMPHATIC VESSELS.

Some of the most important diseases of the lymphatic vessels are caused by obstruction of their channels. This may result from a number of circumstances. Inflammation may produce thickening of the walls of the tube and the deposit of plastic material in such amount as completely to block the passage. The presence of morbid growths or other formations in the immediate neighborhood of the vessels is competent to close the lumen permanently. A tumor may form within a lymph-duct and stop it up, and the same effect may be produced by the presence of living parasites. If the obstruction is not perfect or if there are collateral channels by which the fluid can flow to its usual destination, no harm may ensue. When the lymph cannot pass the obstacle or find side-paths, it is dammed back into the vessels which it occupies and the interspaces of the tissues in which it is formed, and, its volume being constantly augmented by additions at the periphery, the vessels and spaces are over-distended, the walls gradually yield to the internal pressure, and dilatation ensues—a condition called lymphangiectasis.[2] While usually traceable to a definite cause, it sometimes occurs when there is no obvious obstruction of the lymph-vessels. It is sometimes congenital, though usually acquired.

The manifestations of the dilatation dependent upon obstruction are various: in some cases the area affected is very small, even trivial; in others it involves an entire limb; there may be diminutive vesicles or

[1] *Lymphorrhœa* (*lympha* = lymph + ῥέω, flow), a persistent flowing of lymph from an injured vessel; lymphorrhagia (*lympha* = lymph + ῥήγνυμι, break forth), a violent lymphorrhœa.

[2] *Lymphangiectasis* (*lympha* = lymph + ἀγγεῖον = vessel + ἔκτασις = dilatation), dilatation of lymph-channels.

large cystic tumors; the influence upon health may be insignificant or so serious as to destroy life; the dilatation may affect vessels only upon the surface of the body, or it may implicate principally those that are deeply situated; some cases are readily amenable to treatment, others are hopeless from the beginning. The enlargements which ensue from this condition are in many cases hypertrophic: the tissues in which the distended vessels lie having constantly presented to them a far more abundant supply of nourishment than is normal, the appropriation of an excessive amount of pabulum is almost inevitable, and hyperplasia results. This increase in bulk is uniformly an overgrowth of true connective tissue—the most easily formed of all the textures in the body—is frequently enormous, and may produce such compression of included parts as to deprive them of a sufficiency of nutritive material and cause their utter degeneration.

The vessels may be distended so little that the working capacity of their valves is not impaired, in which case each tube presents the appearance of a row of beads; at a later stage the walls are so widely stretched that the valves present no appreciable impediment to the backward flow, and the moniliform variety is replaced by the cylindrical, the vessels having a fairly uniform diameter. Sometimes, certain valves holding better than others, the intervening portion of the tube swells out and becomes a cyst. Such a tumor may also be formed by the bulging out of the side of a vessel where the wall is especially weak. After this pouch has attained a considerable size the connection with the vessel may be severed and the cyst become independent. When a large number of distended vessels lie in contact a continuance of their dilatation may result in the atrophy of their contiguous walls: the thinning process ends in the perforation of the partitions and the establishment of a communication between neighboring cysts. Thus is produced the cavernous form of lymphangiectasis. These cysts or caverns are lined with endothelium and contain lymph. Their walls are generally more resistant than those of the commoner varieties. The inner surface may be smooth and glistening, or rough from the presence of vascular fringes.

When the dilated vessels form a distinct and separate mass, they constitute the disease called lymphangioma, which sustains the same relation to the lymphatic system that hæmangioma (or, as more commonly called, simply angioma) does to the blood-vascular system. These tumors are soft, feel like a bag of earth-worms, and may be as large as a man's fist. They are often found in the inguinal region. A variety of lymphangioma is known as lymph varix.

The minute networks of vessels near the surface may dilate, and the bulging of their delicate walls at points where there is least strength produces little blebs which look like the grains of boiled sago. These vesicles are most frequent on the inner side of the thigh, the external genitals, and the sides of the abdomen. The rupture of one of them may give rise to a troublesome lymphorrhagia. The tubular superficial vessels, when dilated, are cylindrical or ampullary in shape. They occur on the inside of the thigh, the prepuce, the ham, perineum, and at the bend of the elbow. They are soft, movable, and fluctuating. Lymphangitis of a dilated vessel is likely to terminate fatally in a short time.

In erysipelas we have what is perhaps the most common form of

lymphatic occlusion. The disease is characterized by rapidly-spreading inflammation of vessels and spaces in the integument and the tissue just beneath it, with consequent interruption of the flow of lymph, and hence œdema. If the stagnated lymph coagulates, the restoration of the lumen is more difficult than if there is mere stasis. The re-establishment of the current is probable if the attack is of only moderate severity; but if it is intense, and particularly if it is repeated again and again, the damage may be irreparable and permanent œdema ensue.

The lacteals are subject to the same disorders as the other lymphatics, but on account of their situation and relations are not within the sphere of this article.

This outline of the general features and results of the occlusion of lymph-channels permits much more brevity than would otherwise be possible in the presentation of the essential facts concerning several distinct diseases arising from such obstruction.

LYMPHANGIOMA.

Lymphangioma is a tumor composed of dilated lymphatics. It is usually congenital. It is generally filled with a translucent fluid, which is lymph slightly if at all modified. Its favorite sites are the neck, buttocks, groin, armpit, forehead, back of thigh, and the walls of the mouth. The clinical history of the disease is not clear.

A simple lymphangioma is painless, soft, and compressible. Between the walls of the vessels composing it is an amount of connective tissue which varies in different cases, and in the same case at different times, diminishing as the growth increases. The development of cysts indicates a more advanced stage of the disease. As in the growth of these tumors the septa between adjacent component vessels may be absorbed from pressure, so absorption of the walls of contiguous blood-vessels may take place, and by the establishment of a communication between the two kinds of vessels a hæmato-lymphangioma be formed.

Lymphangioma is a benign disease, but it may be attended with alarming debility through the prolonged and profuse loss of lymph escaping from some spontaneous or artificial opening in the tumor. Such discharge, if moderate, constitutes a lymphorrhœa; if of large amount, a lymphorrhagia. Though often spoken of as diseases, they are merely phenomena which may be present in a number of affections of the lymphatic system. They are less likely to occur in the cystic than in the commoner forms. They are not necessarily serious, cases having been credibly reported of the waste of great quantities of lymph without impairment of health; but, on the other hand, lymphorrhagia may occasion a grave anæmia, called "spoliative" by Lebert, who entertained the idea that in such cases the blood was impoverished more rapidly than repair could be effected.

Cystic hygroma of the neck is a cavernous lymphangioma. It occurs in the upper part of the neck, immediately beneath the occiput. It is smooth, nearly globular, a perpendicular groove dividing it into lateral halves. The tumor may extend well into the region of the shoulders. The system of the patient is usually enfeebled, and seems to be peculiarly liable to pulmonary tuberculosis.

The only proper **treatment** for lymphangioma is removal. This should be complete, as there is danger of lymphorrhœa if any portion of the dilated vessels is permitted to remain.

LYMPH VARIX.

Lymph varices are either superficial or deep. The former are either cylindriform or beaded. The penis and groin are their favorite sites. They are usually temporary, and disappear when the obstructing cause is removed. If permanent and very annoying, they may be excised.

The deep varices present grave difficulties. They occupy inaccessible positions in the abdomen. In advanced stages they are liable to be mistaken for herniæ, inasmuch as they fill the inguinal canals; indeed, it is said that the diagnosis is rarely made correctly. The employment of puncture as an aid in determining the character of these growths has been recommended by an illustrious surgeon, but the possibility of starting an uncontrollable lymphorrhagia should make us hesitate to adopt this advice.

No **treatment** avails anything, and the **prognosis** is always bad.

LYMPHŒDEMA.

Any interference with the normal flow of the lymph in its channels is liable to cause transudation through their walls into the areolar tissue. The resulting condition is known as "lymphœdema." The situation of tne obstruction is generally to be determined by ascertaining to what part of the lymphatic system the affected area is the periphery. If the obstacle is removable with safety, the rational treatment is clear. By the compensatory enlargement of collateral channels Nature once in a great while affords a measure of relief which surgery cannot give. Bandaging with elastic materials may mitigate the evil condition somewhat. Often, however, the affected member becomes so monstrous a burden that its removal must be considered. After ablation of a cancerous breast, for example, the glands in the axilla may so enlarge and press upon the vessels as to cause prodigious increase in the size of the corresponding limb, with severe pain and interference with the movements of the joints. If the progress of the disease is slow, life may be prolonged and comfort greatly enhanced by amputation. The tissues in lymphœdema are brawny and inflexible, and lymph flows freely from their cut surfaces. This condition is not necessarily a serious obstacle to the healing process, as demonstrated in a case of amputation of the thigh close to the great trochanter, in which I was obliged to use a chain-saw in the division of the bone on account of the impossibility of turning back the flaps sufficiently to permit the use of the ordinary instrument. The healing was rapid and perfect.

Macromelia.[1]—Congenital and acquired occlusion of lymph-channels, with the consequent dilatation of those passages which are peripheral to the point of obstruction, sometimes produces results which differ materially from those previously discussed in this article. There is no

[1] *Macromelia* (μακρός = great + μέλος = member), a form of monstrosity characterized by great enlargement of some member.

FIG. 378.

Macrodactylia.

lymphangioma (at least none conforming to the ordinary rules of development followed by this growth, though the deformity in question is sometimes classed under that head), no varix, no œdema, no lymphor-

FIG. 379.

Macrodactylia.

rhœa; only an enormous and disfiguring growth of some member, as a finger, toe, hand, foot, forearm, leg, or even an entire limb, upper or

Fig. 380.

Macropodia.

lower. The accompanying illustrations, from photographs of one of my patients, convey an excellent idea of certain phases of this class of monstrosities. In this case parts of both hands and the whole of one foot and leg were involved, or, technically, there were macrodactylia[1] and macropodia.[2]

The **etiology** of these cases is obscure. Their **treatment** must be fashioned on general principles. If the growth interferes with function or comfort, amputation is justified, and even demanded.

Chylocele.—A surgeon occasionally finds that a scrotal enlargement, diagnosticated as a common hydrocele, contains a milk-like fluid, upon which, if it is allowed to stand, cream rises. This disease has been called chylocele,[3] with the idea that the fluid is chyle; galactocele, because it looks like milk; and liporocele, from its oily nature. In no reported case has the real nature of the disease been suspected before operation.

The **clinical history** does not differ from that of hydrocele. The wall of the sac may be very thick and hard, its lining smooth, shining, and pearly, with a granular nodule at some point enclosing the mouths of channels which communicate with the spaces of the areolar tissue; or the lymphatics of the tunica vaginalis may be over-distended from obstruction of the normal current of lymph resulting from gonorrhœal inflammation of the inguinal glands. The non-translucency of the tumor under the usual candle-test for hydrocele should lead to suspicion of the character of the contained fluid; but the failure to make a correct

[1] *Macrodactylia* (μακρός = great + δάκτυλος, finger), excessive size of the fingers.
[2] *Macropodia* (μακρός = great + πούς, foot), abnormal size of the feet.
[3] *Chylocele* (χυλος = juice + κήλη = tumor), chyle-tumor.
Galactocele (γάλα = milk + κήλη = tumor), milk-tumor.
Liporocele (λίπος = oil + κήλη = tumor), tumor containing oil.

diagnosis in the case need occasion no chagrin, considering the infrequency of the disease and the innocence of the error.

The **origin** of the condition is not demonstrated. Reporters of cases seem not to have thought to examine the blood for filaria, and in other respects our sources of information are rather unsatisfactory. Probably the disease is caused by some incomplete obstacle to the upward current of chyle, a portion of which, in some obscure manner, accumulates in the vaginal tunic of the scrotum.

The **treatment** is precisely that for hydrocele. Injections of tincture of iodine seem to have been preferred in the main, but probably the advantages of liquefied carbolic acid would be as evident in the therapeusis of this disease as in that of the affection which it so much resembles in its clinical aspects.

Filariasis.

Among the various causes of serious obstruction of lymph-channels, that which should be accorded the first rank is the condition known as *filariasis*. Knowledge of the parasite which gives its name to this pathological state has been only recently acquired, but the demonstration of the connection between the presence of the worm and certain long-known diseases has been so completely made as to put it beyond question that the one sustains a causative relation to the other. The principal maladies which result from filariasis are elephantiasis Arabum, lymph-scrotum, and chyluria. These diseases are endemic over one-half of that portion of the world which is most densely populated, and, while they are far from common in America—are, indeed, of the nature of curiosities with us—they are occasionally encountered even in the Northern section of our country, and it has recently been announced that filariasis has become actively endemic in our Southern States. When one contemplates the method by which the parasites are propagated, the offensive and incapacitating, if not often fatal, character of the diseases which they cause, and the possibility of a somewhat rapid dissemination of them all over the land, the importance of a diffusion of information on the subject becomes manifest.

It is not intended to convey the idea that filariasis is the sole cause of the group of diseases under consideration: doubtless anything else which produces an obstruction in a lymph-channel as completely and permanently may occasion practically the same pathological phenomena. But in the large majority of cases filariasis is the prime etiological factor.

After the establishment of a filarial disease it is unlikely that any means which are not surgical will effect much for the patient, even in the direction of alleviation, and there are many cases in which nothing yet attempted gives relief, the removal of the cause being impossible. In the prevention of the filarial diseases, however, it is probable that nearly perfect results are attainable, though by methods which are not at all surgical.

In 1866, Wucherer discovered in the urine of a patient suffering from chyluria a parasite belonging to the nematoid family. In 1872, Lewis found in the blood of an East Indian who had diarrhœa a number of actively-moving worms, exactly those which he had independently

discovered two years before, and had come to expect in the urine in every case of chyluria. Soon he detected the same parasite both in the urine and the blood of a patient with chyluria; presently he found the nematoid in the blood of an elephantiac, and then in the fluid drawn from a lymph-scrotum. He named the creature *filaria sanguinis hominis*—the thread-like worm of the blood of man. As seen in the blood, it is a very actively-wriggling snake-like animal, about the eightieth of an inch long, and with a width not quite equal to the diameter of a colored corpuscle of the blood. It appears to have a delicate, transparent sheath, which is supposed to be the chorional envelope retained and stretched, and within which the body is alternately extended and retracted very rapidly; and the impression made on the observer is that the worm is provided with a lash. The wriggling does not seem to produce locomotion, but it establishes to-and-fro currents in the drop of blood on the slide of the microscope, by means of which the recognition of the hæmatozoa is facilitated; for when they are dead and motionless it is often very difficult to distinguish them from vegetable fibres, fibrinous coagula, and urinary casts. The alleged observation of an alimentary canal in the filaria needs confirmation. The creature is without sex. Objectives of high power are not needed in searching for it: a half-inch glass is sufficient. Being found, it is best to substitute a quarter-inch objective or a somewhat higher one. If the slide is kept at the ordinary temperature of a living-room, the worm may survive three days. The number of these hæmatozoa in a single patient is amazing: one estimate has placed it at thirty-six million.

A most curious circumstance about them is the usually-observed fact that they have a periodical daily migration. Toward evening an examination of the blood detects but a few of them, but hour by hour their number swells until midnight, when the blood is alive with them. From this time they begin to disappear, until by nine o'clock in the morning (sometimes as early as six o'clock) the most studious scrutiny fails to find one. All through the day they elude observation, but near the close of it they appear as before for their evening of mad frolic. A change in the meal-hours of the patient effects no modification in their behavior, though this circumstance produces, as would be anticipated, a marked change in the times when chyle appears in the urine. Experiments have shown, however, that the turning of night into day in the matter of sleep determines a complete reversal of their habit, as they then appear in the blood during the hours when they are usually conspicuous by their absence, and cannot be found at the times when they generally swarm in countless myriads. But absence during the daytime is not invariable, even where the usual hours of sleep are undisturbed; and this gives support to the theory recently advanced by Manson, who has given special attention to their study. He claims to have differentiated three varieties of *filaria sanguinis hominis:* that of Lewis, which he distinguishes by the name *nocturna;* another, which he calls *major* or *diurna;* and a third, christened *minor* or *perstans.* The last, he says, has no periodicity of appearance, and is in every way smaller than the others, which equal each other in size, but differ in their hours of exercise. With no more light on the subject than we have at present it does not seem profitable to dwell on these distinctions. It has been observed

that fever interrupts the regularity of the periodical appearance of the hæmatozoa.

Soon after the discovery of these minute worms it was rendered almost certain that they were the embryos of an unknown parent, to which, rather than to the offspring, should be ascribed the harm done in connection with their residence in the human body; and probability gave place to proof in 1876, when Bancroft of Australia found and described the prolific parent of this multitudinous progeny. In his honor it has been dubbed *Filaria Bancrofti.* It has a hair-like, smooth body, about three and a half inches long and one-ninetieth of an inch thick; its mouth is circular and has no papillæ; its neck is one-third as thick as its body. Its slender alimentary canal runs from the club-like head nearly to the blunt tail. The vagina, which opens near the head, is short and terminates in a bicornous womb, which occupies the remainder of the body and is crammed with embryos. The parent worms may display great longevity, if we judge from the number of years that the urine has been known to be constantly chylous. The possibility of the renewal of filarial disease by the repeated introduction of maturing parasites is to be entertained in this connection, though it seems unlikely that a successive series of them should occupy substantially the same position in the lymphatic system for a considerable number of years. The two sexes probably live together, and always in a lymphatic vessel of some size. Their progeny, which are viviparous, are carried in the lymph-stream through the thoracic duct, and thus enter the blood-vascular system. The character of the disease brought on by filariasis is determined by the vessel selected by the parents for their residence and by the integrity of the lymphatic glands.

The method by which filariasis is propagated is of much practical interest. The unhappy host of the lymphatic worm is stung by a female mosquito, which, in filling her stomach with his blood, ingests a large number of filaria embryos. She then betakes herself to some pool, where she can quietly digest her meal and lay her eggs. A large proportion of the parasites are digested with the blood, but about one-tenth of them escape this process. It is said that a certain mosquito which can digest canine filariæ cannot thus affect the human variety. However this may be, a part of the creatures are spared destruction in the body of the insect; and when the latter, having fulfilled her reproductive duty to her species, dies and falls into the water, the filariæ which have had the fortune to survive, having developed considerably during their four or five days of sojourn in the alimentary canal of the culex, are liberated into a medium which is peculiarly adapted to promote their further advancement. They grow to the length of half an inch, and then, being swallowed in the water drunk by some human being, are led by instinct to the lymphatic system, whither they arrive, presumably, by boring their way through the intervening structures. A worm, having reached the thoracic duct or some other large lymph-vessel, sets up ulceration or inflammatory thickening, by this means producing stenosis of the channel. The lymph is dammed up on the distal side of the obstruction; the vessel dilates; its valves become useless; its walls either burst from internal pressure or, what is more probable, experience a compensatory hypertrophy; the region from which the channel has previously collected

lymph is saturated and swollen with the constantly accumulating fluid, and the tissues undergo changes of a characteristic nature.

Nothing in detail is positively known of the life-history of the helminth from its entrance into the human body until its full development. Several parent worms have been found in a single case, but in others it is nearly certain that one individual, or, at most, one couple, has inaugurated all of the trouble in a filarial disease of great severity. As already remarked, there are many cases of occlusion of lymph-channels not due to parasitic plugging, but it is imaginable that some of the cases which do not seem to be filarial are so in reality. For instance, an unmated male or an unimpregnated female might cause occlusion, setting up the local disease about itself, as just described, and bringing on elephantiasis; but in such a case there would be no embryos in the blood.

Several theories have been broached to account for the periodicity in the appearance of the embryo filariæ. It is conjectured that the mother has a daily parturition, in which some millions of offspring are started on an extra-uterine career which is destined to be cut short before the next brood is born, so that we do not find the hæmatozoa by day, because they are all dead. The manner in which the corpses of this multitude are disposed of in the system seems to have baffled the fertile imaginations of the promulgators of this hypothesis. Others have supposed that the filariæ collect in the lymphatic system or in some internal organ during their absence from the blood, but no facts support this idea. Perhaps it is worthy of note in this connection that the embryos seem to have no locomotive capacity, and are passively carried in the blood. If they behave in the blood-vessels as they do on the stage of the microscope, they do not actively seek an asylum anywhere, but are gathered into a retreat if they really spend their days out of the blood. To this notion there are objections which it is not important to present. It has been earnestly argued that the tonus of the cutaneous capillaries during the waking periods determines a degree of contraction of their calibre which prevents the escape of the tiny worms; but it is somewhat difficult to understand the selective principle on which the vessels act so as to permit the passage of blood-corpuscles and prohibit that of bodies of a somewhat smaller diameter. One ingenious theorist is persuaded that the nocturnal presence of the filariæ in the blood is providentially designed to play a part in the perpetuation of their kind, because the mosquito, which is to act as intermediary host, pursues her musical and sanguinary vocation mostly by night; but this does not account for the equally interesting and perhaps important desertion of the blood by these minute beings during the day, and, at best, is merely a fantastic illustration of a style of philosophizing which is not content unless announcing its comprehension of the intent in all creation, and, fortunately, is going out of fashion.

The hæmatozoa themselves are not the cause of disease in their host, and a mature worm may remain lodged in a lymph-channel for years without serious result, though this is somewhat phenomenal. In the Eastern countries, where filariasis is endemic, 10 per cent. of the natives entertain these unwelcome visitors, and yet a considerable proportion of them have good health. The majority, however, are less fortunate, and are afflicted with lymph-scrotum, chyluria, elephantiasis, lymphangitis,

lymphadenitis, lymph varix, phlebitis, hæmaturia, hydrocele, or frequent attacks of fever which in many respects resembles malarial disease, and some have two or more of these manifestations of filariasis simultaneously.

Since the **etiology** of this class of diseases has been measurably understood various methods of **treatment** have been devised with a view to the destruction of the parent worms or their progeny, or both. Thymol, in doses of from one to five grains thrice daily, has been asserted to ensure the disappearance of the filariæ from the blood, and with equal positiveness it is declared to be impotent to produce any effect upon them, even when two hundred grains have been given daily. Gallic acid has been much employed, and may be of use where hemorrhage is a feature of moment; but it has little if any worth in other respects. All other medicines which have been tried seem to be equally valueless.

To say nothing of the improbability of destroying the parent by the administration of any drug which would not at the same time cause serious mischief in the system, if not the death of the patient, it is, as Manson has graphically stated, as illogical to attempt to cure certain of these diseases by trying to kill the offending filaria as to endeavor to cure established heart disease by salicylates or chronic urethral strictures by astringent injections. The parasite starts the pathological process, but, the damage to the lymph-vessel and the neighboring structures having been done, and permanent occlusion of the passage having resulted from this, the presence of the helminth is not necessary for a continuance of the condition. In a small proportion of cases the parent worm is lodged in a locality which is accessible to the surgeon, and in the course of the ablation of a diseased organ it is taken away; but this ejectment of an undesirable tenant does not undo the malign work which he has accomplished, upon which mainly the disease and the sufferings of the patient depend. Still, it is a satisfaction to be able to assure a victim of a loathsome, disfiguring, crippling, and sometimes mortal disease that he is no longer the residence of a disgusting animal, and that the possibility of further lesion on account of its presence has been extinguished. When the intruder cannot be reached, the proper treatment is such as would be advised in a case of acquired varix in an inaccessible region—rest, elevation, lowering of the tension in the lymphatic vessels by saline cathartics, limited and mostly vegetable food, and as great an abstinence from fluids as the patient can reasonably be expected to endure.

The true treatment of filariasis is unquestionably the prophylactic, and there is no theoretical difficulty about stamping it out by hygienic measures. Practically, the same impediments will be encountered that sanitarians always find in the way when even their wisest and most benevolent plans are put in execution—the ignorance, indifference, carelessness, and recklessness of the people who are most to be benefited. In the countries where filariasis is prevalent all water designed for drinking purposes should be filtered or boiled, or—best of all—both filtered and boiled. That boiling will destroy these animals needs no demonstration when their physical characters and natural relations are considered; but one should not be accused of excessive squeamishness if he entertains a

prejudice against the ingestion of nematoids, even if they are dead, and their elimination by filtration from water contaminated by their presence is suggested as a preliminary to boiling, less in the interest of health than for the satisfaction which it will afford to a pardonable fastidiousness.

With a knowledge of filariasis we are prepared to appreciate the phenomena of the principal diseases to which it sustains a causative relation.

ELEPHANTIASIS.

This name is derived from that of the animal whose leg is suggested to the mind of the most casual observer by the appearance presented by the lower limb of a man in whom this disease has developed to an advanced stage and in its most characteristic situation. The word *Arabum* is often affixed to the name to distinguish it from *elephantiasis Græcorum*, but no confusion will arise from our using the abbreviated term.

The cause of elephantiasis was unknown until recent years, but is now demonstrated to be the occlusion of a lymph-channel by the occupancy of a filaria Bancrofti. This parasite has a marked predilection for residence in the lymphatics of the lower part of the body, and, as a consequence, elephantiasis is rarely situated above the level of the umbilicus.

Considering, first, the member which, when profoundly affected, easily justifies the name of the disease, we observe that there appears somewhere on a lower extremity, generally in the toes, an erysipelas, which we have found to be an inflammation of lymph-spaces and channels, principally those in the subcutaneous areolar tissue. This is attended with pain, often violent; evidences of inflammation of lymph-nodes; much swelling, and sometimes ichorous discharge, and systemic disturbance, as shown by fever, nausea, and perhaps vomiting. When the attack is over some thickening of the skin and subcutaneous tissues is observed. After an interval of uncertain length a second visitation of erysipelas occurs, with a repetition of the phenomena just recounted. This, too, disappears, but leaves the integuments which have suffered thicker and more dense than before. Thus one recurrence follows another, the subsidence of each disclosing a greater involvement of the affected parts, until the hypertrophy in extreme cases is so enormous that the skin is four inches thick. As the enlargement progresses the attacks of inflammation and fever are less violent and painful, and the health may be good in the intervals. When the disease is fully established the skin is seen to be thrown into immense transverse folds and ridges, between which are deep depressions. The areas of skin buried in these sulci rub against each other, and eczema often results. Ulcers, open or thinly covered with crusts, exist at numerous points and discharge foul-smelling sero-pus; lymph oozes from fissures and broken blebs; and the discomfort, which is generally great from the weight of the limb, is sometimes aggravated by pressure of the growth upon included nerves. In some cases the hypertrophy is said to take place without manifest inflammation.

The skin is not in the same condition in all cases. It may be smooth,

the outer layer of the epidermis being unaffected, and the disease is then called *elephantiasis glabra;* hard, rough, and white, *e. dura;* soft and grayish, *e. mollis;* warty in appearance, from prodigious elongation of the papillæ, *e. verrucosa;* knobbed, *e. tuberosa;* brown, from increase of pigment-cells, *e. fusca;* black, from an exaggeration of the last-named condition, *e. nigricans;* covered with eczematous eruption, *e. eczematosa.* These names are rehearsed, not because I regard them as valuable or at all necessary, but because as they exist in our terminology (possibly on account of the pedantic desire of some authors to display their delicacy of discrimination and their ability to apply Latin adjectives), it is worth while to know their meaning. There is no important difference in the essential conditions behind all these alleged varieties, and two or more of them often coexist in a patient.

There is a true hyperplasia of the fibrous elements of the corium and subcutaneous areolar tissue, with a copious albuminoid deposit in the spaces of the latter, and immense growth of the papillæ. The newly-formed tissue may be rich in cellular elements or it may be poor in them. The hyperplasia is due to over-nutrition, from the accumulation in the ultimate lymph-spaces of the nourishing elements, and the gluttonous appropriation of this unusually abundant pabulum by the tissues to which it is so insistently presented. A section of this hypertrophied structure displays a white, usually homogeneous material, so dense that the knife encounters almost as much resistance as in cutting cartilage, and saturated with lymph, which oozes freely from all parts. The blood-vessels are enlarged; the connective tissue between the fasciculi of the muscles is increased like that in the integuments; the true muscular tissue is in a stage of fatty degeneration; and the periosteum has so exceeded the normal in its nutritive function that new bone, generally in disfiguring protrusions, has been formed, sometimes to such an extent as to produce fusion at the joints. The morbid action rarely extends above the knee. In severe cases ulceration may attack the toes, and ultimately destroy them, leaving foul sores which heal reluctantly or not at all.

During the early, acute period of the disease rest, elevation of the limb, and perhaps fomentations, are required locally, and anodynes and antipyretics as occasion demands for the general system. After this stage general **treatment**, directed to the cure of the disease, is without avail; but it is often necessary to protect the patient against the debility which is induced by various circumstances of the malady. Change of climate was a routine prescription before the etiology was understood; but with our present light on the subject this recommendation would seem to have no value, excepting such as always attaches to advice for removal from an unhealthful into a salubrious region.

Surgery offers several modes of relief of more or less value. Of these the simplest is persistent compression, best accomplished by means of a pure-rubber bandage applied as snugly as the patient can bear without distress. Cure will not be effected by it, but prevention of further growth is sometimes achieved, and often great relief of the discomfort. Ligation of the main artery of the limb has been practised with temporarily good results; but on the full establishment of the collateral circulation the undoing of the cure is begun, and the old condition is reinstated before long. Section of the great sciatic nerve has been tried with apparently

good effect, but observation of the results is too limited to warrant a positively favorable opinion of it. Removal of the limb by amputation is the only radical and really commendable operative procedure to be pursued in these cases. The results are usually excellent, the mortality being small and the relief from a hideous burden complete. Esmarch's bandage is of great use in protecting against hemorrhage, which is apt to be serious without it.

Elephantiasis Scroti.—When elephantiasis attacks the external genitals, structural changes are wrought nearly identical with those brought about in the lower limb. The symptoms from the onset are very similar—fever, pain in the loins and groins, swelling of the testes and their cords, with great suffering, inflammation of the skin, and sometimes fœtid and irritating serous exudation. Allowing for the difference in the organs involved, the symptoms are substantially alike in the two localities. The enlargement of the spermatic cords and the dragging of the heavy tumor upon them are an invitation to inguinal hernia which is often accepted. The evidences of acute trouble subside only to recur again and again, and each attack leaves its mark in an addition to the hypertrophy which was slightly noticeable after the first. The integuments of the scrotum become enormously enlarged, far outgrowing the length of the penis (unless this organ also has a share in the disease), which may be imbedded beyond sight in the huge mass at the bottom of a conical well. The lymph-vessels on the surface become varicose in spots which are irregularly distributed over the area involved, and when opened, spontaneously or otherwise, give exit to lymph in considerable quantity. The growth sometimes attains an appalling size, one being recorded which weighed one hundred and sixty pounds. Frequently it hangs as low as the knees, and the patient uses it as a stool to sit upon; and in some cases locomotion is impracticable unless the tumor is deposited in a wheelbarrow which the patient trundles before him. Subsequently to the inflammatory attacks, the intervals between which become longer and longer until the febrile movements may cease altogether, the suffering is mainly due to the size and weight of the growth. The disease rarely kills, but it places many of its victims in a condition to which death would seem to be preferable. Mortification occasionally destroys a part or nearly the whole of the mass; ulcerations are frequent; and the patient is constantly in danger of septic poisoning from these sources.

This, like the other elephantiac diseases, is not yet common outside of tropical or semi-tropical countries, but it may appear sporadically in temperate climes, as evidenced by a case under my observation occurring in the person of a man always a resident of New England. Here the penis, as well as the scrotum, was involved, as is plainly seen in the accompanying picture from a photograph (Fig. 381). In the female the organs affected are the homologues of those attacked in the male—namely, the labia majora and the clitoris. It rarely attacks those who are under the age of twenty years or over that of forty, and it is much more common in men than in women. The course and termination of the disease in woman are so like its manifestations in man that no detailed description is demanded.

The compression of the tumor with a rubber bandage may afford

some amelioration, but complete ablation is the only treatment which is of much account. Before we had Esmarch's method of preventing hemorrhage the operation was apt to be formidable on account of the copious bleeding. For a few hours before the operation the patient should lie on his back, with the tumor supported in an elevated position, in order to

FIG. 381.

Elephantiasis occurring in Maine.

drain it of fluids as far as possible by gravitation; herniæ, if present, should be reduced; and hydroceles, which are apt to exist, evacuated. Then the Esmarch band is to be applied around the neck of the mass. In extreme cases it is an advisable precaution to have the abdominal aorta compressed, or, at least, to have a competent assistant detailed to apply compression if it becomes necessary. The incisions are made along the dorsum of the penis and over the course of the cords. These organs and the testicles are to be dissected out—the tunica vaginalis being avoided, if possible—and all turned up on the belly. The perineal connections are then severed and the mass removed. Great care must be taken to tie all vessels. The veins, instead of collapsing, as they do in normal tissues, are held wide open by the rigidity of the surrounding structures, and it is often difficult to secure them. It should be superfluous in these days to insist upon the absolute need of the strictest asepsis. The statistics of the operation, having been gathered before the Listerian principle was appreciated, are far less favorable than any good surgeon would obtain now. About one in six used to die in consequence of ablation. Shock is the thing which is chiefly dreaded at present, and will doubtless still claim many victims even on the operating table.

LYMPH-SCROTUM.

This disease is called by Rindfleisch, "*pachydermia lymphangiectatica;*" that is to say, the thickened-skin disease, due to dilatation of the lymphatic vessels. It is also called *chyloderma, varix lymphaticus,* and

nævoid elephantiasis—names which are suggestive of important features of the disease. It is really a form of elephantiasis, having its favorite haunts in the same countries; presenting similar appearances, both clinically and pathologically; sometimes coexisting with elephantiasis in the same person; frequently developing into the graver disease; having the same kind of febrile and inflammatory movements; and depending upon exactly the same cause—to wit, obstruction of lymph-channels, and this commonly on account of filariasis.

Fever inaugurates the disease, and is quickly followed by acute inflammation of the scrotum and of the lymphatic vessels of the groin. The skin is left thickened, and, as the attacks are repeated many times, each leaving its contribution to the part, the integument comes to assume a peculiar and characteristic corrugation. The lymph-vessels of the scrotum become dilated and varicose; the tissue immediately beneath the epidermis is channelled by a multitude of intercommunicating sinuses and cavities—the dilated, superficial, subpapillary plexus of lymphatics. A probe inserted into one of them from the inner side of the tumor and directed outward almost emerges, so thin is the layer of skin covering its end. The upper parts are altered as in ordinary elephantiasis. The surface is besprinkled with small vesicles, which burst spontaneously and discharge a fluid resembling lymph or chyle and containing filaria embryos. The loss of this fluid may be very great (*lymphorrhagia*) and endanger the life of the patient. In one reported case the mass had an outer rind half an inch thick, and the interior was entirely gelatinous; the vesicles on the surface communicated with the central part.

The enlargement, it will be seen, is less due to hyperplasia of the connective tissue than to varicosity of the lymph-vessels of the skin. The fluid, when milky-looking, will sometimes coagulate. The discharge is not usually constant, but irregularly intermittent. A large quantity of the liquid may be lost daily for a long time without undermining of the health. The size of the tumor may markedly diminish during the period of discharge, and rapidly increase on the cessation of the flow. The exudation may alternate with attacks of chyluria. After many years of periodic activity the discharge may cease, and the scrotum gradually assume the characteristic appearances of ordinary elephantiasis.

Filariæ sometimes cannot be found in the blood, even though they are constant in the voided lymph. This peculiarity depends upon the selection by a maturing worm of a lymph-vessel in or near the upper part of the scrotum for its abiding-place. The lymphangitis which the creature always excites extends to the nearest related nodes, and sets up a lymphadenitis of such intensity that their passage-ways are completely blocked, and, consequently, the lymph which should flow through them is dammed back upon the region in which it is formed. The embryos, being unable to escape into the general circulation, are imprisoned in the lymph of the affected part. When the fluid is chylous there is probably an occlusion of a lymph-duct at some point above the entrance of some lacteals into the receptaculum, and perviousness of vessels below.

No other **treatment** than removal with the knife is worthy of a trial. Repeatedly the offending helminths have been found at the time of the operation.

CHYLURIA.[1]—When the urine contains emulsified oil the condition is called *chyluria* or *lymphuria*. It is not usually ushered in by any well-recognized premonitory symptoms, but occurs suddenly, the patient observing, to his surprise, that his urine has a milky appearance and is increased in volume. Often, coincidently, there are uneasiness in the lumbar regions, the bladder, and the urethra, and some debility and depression of spirits.

The urine quickly coagulates on standing, becoming a soft solid; but in a few hours the clot disintegrates, a cream rises to the top, and the fluid undergoes rapid decomposition. Coagulation may occur within the bladder, in which case micturition cannot be performed until these masses break down. It is not uncommon to find blood in chylous urine, either generally diffused or, what seems to be more frequent, in shreddy clots. The amount of fluid voided from the bladder is greatly augmented, one hundred and twenty ounces being the daily average in one recorded case during many months. The oily material may be found constantly in the urine for a long time, and then disappear as unexpectedly as it came.

A patient may have several attacks of chyluria at varying intervals, and be entirely free from urinary ailments between the seizures. Chyluria occasionally alternates with the discharge of milk-like fluid from the ruptured vesicles of lymph-scrotum, with which disease it is often associated. There may be no serious impairment of health, but there is liable to be very great debility, doubtless dependent upon the waste of so large an amount—perhaps a considerable proportion—of the nutritious material taken as food and digested with the expenditure of much vital energy. The disease has the same geographical distribution as elephantiasis.

The **pathological anatomy** is not well understood. The presence of filaria embryos in the blood of most of these patients, and also in their urine when it is chylous, is the most prominent and almost the only circumstance which is common to the large majority of cases. The phenomena are in general exceedingly capricious. It is practically beyond dispute that the disease depends primarily upon filariasis. Numerous explanations of the details of the disease have been offered, but none are entirely satisfactory, partly because they are unreasonable, but more because they are inconsistent with the post-mortem appearances. The seriousness of many cases gives an interest to the affection which is more than scientific. The rare cases in which no filariæ are found in the blood depend upon some condition which is altogether conjectural.

The amount of chyle voided may be somewhat diminished by restricting the patient to a vegetable diet and a small amount of liquid. In this way the lymph-pressure may be lessened, and it has been suggested that this may result in the healing of defects in the walls of the vessels, but no facts have been adduced in support of this hypothesis. The strength must be held up by tonics. Turpentine and astringents, especially gallic acid, have been vaunted for their supposed efficacy. It will be suspected, however, by the whimsicality of the changes in cases

[1] *Chyluria* (*chylus* = chyle + οὖρον = urine), a discharge of chyle with the urine. *Lymphuria* (*lympha* = lymph + οὖρον = urine), same as chyluria.

where no medicine has been administered, that recovery or improvement during the exhibition of these drugs is an illustration of *post* rather than of *propter*. It will continue to be the part of the prudent practitioner to pronounce a guarded prognosis in chyluria.

Affections of the Lymphatic Glands.

INFLAMMATION OF LYMPHATIC GLANDS.[1]

From the list of classes of circumstances formerly invoked to account for inflammation of lymph-nodes the advance of science compels us to expunge two—the idiopathic and the diathetic. As stated on a previous page, it is difficult to understand how a lymphangitis can be produced except through the agency of micro-organisms. The lymph-glands have a perfect continuity of structure with the vessels, and we are compelled, therefore, to recognize the efficiency of the microbes, which are responsible for the inflammation of the vessels, in the production of the same process in the glands. If there is no idiopathic inflammation for the channels, there is none for the nodes. We discard the diathetic causes also, because it is so clearly demonstrated that in typical cases cited to sustain this theory—cancer, for example—the involvement of the glands is due to the introduction into their sinuses of infectious material from a malignant mass in the region from which these organs receive their lymph. It is not a matter of diathesis: it is one of the absorption of a living poison and its detention in the first convenient resting-place. Traumatism should be considered a cause of lymphadenitis in those cases only in which the inflammation is occasioned by violence applied directly to the gland; for, if the lesion is elsewhere and the node is subsequently inflamed, the morbid process in it is secondary to the injury and directly dependent upon the absorption of material (probably septic) from a distant point. Thus, the field of trauma as an etiological factor in the case is reduced to limits which are extremely narrow. Finally, then, it amounts to this: Almost always lymphadenitis is caused either by extension of inflammation from a diseased tributary vessel or by infection from a more or less distant focus of dissemination, the irritant poison being conveyed to the gland through lymph-channels, which may give passage to the toxic agent without themselves experiencing any harm.

Lymph-nodes are exceedingly prone to inflammation. This may be either acute or chronic. As the two kinds present many points of difference, it is desirable to consider them separately. In both classes there is a tendency to inflammation of the connective tissue which surrounds the gland (*periadenitis*).

Acute Inflammation of Lymphatic Glands.—A lymph-node which previously had never attracted the attention of the patient suddenly makes its existence conspicuous by its swelling, pain, tenderness, and heat, and often, too, by redness of the superjacent skin—in short, by the familiar indications of inflammation. This process may invade one or more of the neighboring glands and the adjacent tissue. In the former case there is a multiplication of the affected area; the latter

[1] *Lymphadenitis* (*lympha* = lymph + ἀδήν = gland); *Adenitis* (ἀδήν = gland).

event is announced by an increase of the swelling and by œdema. The movements of the part of the body where the disease is situated are instinctively reduced to a minimum to avoid the suffering which they induce; but as long as there is perfect immobility the discomfort may not be severe, and there is generally little fever. Naturally, the degree of local distress and systemic disturbance is largely dependent upon the character of the causal irritant, the extent of the disease, and the general condition of the patient. If the morbid action is not promptly arrested, suppuration, to which there is a marked inclination, is almost inevitable. This event is evidenced by softening, both of the node and of the overlying integument. When a number of glands are involved simultaneously, the individual collections of pus may combine by destruction of their adjacent walls and form one large abscess. The evacuation of the pus is succeeded in most cases by rapid healing, but sometimes there is little effort at repair, and an ulcer is established; or the destructive process may invade the areolar tissue and sinuses may result. Such unfortunate sequels depend upon a depraved condition of the system. Other terminations of lymphadenitis are mortification, caseation, chronic inflammation, fibrous induration, and calcification.

In most cases the disease is excited by materials brought by the lymphatic vessels, bacteria and the poisonous substances produced by them being the chief offenders. Often we are unable to reach a positive conclusion as to the cause of the trouble.

The chief pathological change in this disease is the vast increase in the number of cells in every part of the gland. This may be accounted for in various ways: by the more than normally rapid subdivision of the cells of the gland; by the mechanical detention of leucocytes which enter from the lymph; by immigration from the blood-vessels; but we are unable to say positively whether it is mainly one or another, or a combination of them, which does the work. When resolution occurs, these superfluous elements are disposed of in several ways: by fatty degeneration, by coagulation-necrosis, by exportation in the lymph-stream, and perhaps by other means. The channels in the gland are more or less completely blocked by the inflammatory process, and the node thus acts as a catch-basin not only for the lymph, but also for the injurious agents contained in that fluid. If the occlusion is not relieved, permanent œdema of distal parts may result.

Acute adenitis demands very different **treatment** from that which is suitable for the chronic. First, the cause of the inflammation should be sought, and, if possible, removed. All authorities agree that absolute rest is of the greatest importance and should be insisted on. Leeches applied close to the periphery of the swelling are of service in arresting the inflammatory action before the occurrence of suppuration. The repeated application with a brush of equal parts of carbolic acid and glycerin is highly recommended. If such measures do not produce the desired effect in two or three days, more heroic means must be adopted. Probably the most valuable is the injection of the gland with carbolic acid. Authorities differ in their advice concerning the proper strength of the acid for this purpose, one considering a 1 per cent. solution generally sufficient, and another employing it as strong as possible; that is, merely liquefied. This would seem to imply that the worth of the

method depends more upon the drug itself than on its degree of dilution. There is hardly room for disagreement as to the method to be pursued in performing the little operation. The skin of the region and the needle of the hypodermic instrument having been sterilized, the point is introduced nearly through the gland in the centre of its long axis. It is then slowly withdrawn, the fluid being injected all the way along until the needle is almost free from the gland. From five to thirty minims are to be deposited in the node, the amount needed varying according to the strength of the preparation and the size of the mass to be treated. A very large measure of success follows the use of this method, but it must be used before pus forms in order to get the desired result. The anodyne effect of the acid is pronounced; its antiseptic virtues will hardly be questioned. The injection may well be succeeded by firm and continuous pressure for a few days, but this is not advised by all who use this treatment. When abscess forms the pus should be let out through a free incision. If there are bands or thick, adherent pus, the cavity should be curetted carefully, swabbed out with some antiseptic, and packed with gauze. After a few days a deep suture may do excellent service in expediting closure. Fistulous tracts must be laid open, the pyogenic surface removed, and the cavities treated in the manner just prescribed.

Many other plans of local therapeusis have been advocated. Aspiration of the pus and irrigation of the cavity with an antiseptic is one of them, but it is less certain and much slower than proper incision. Removal of the entire abscess is highly vaunted in some cases, but it is probably rarely needed. Blisters have been much used in the past, but should be discarded for less painful and more efficacious measures. Iodine in any form is mischievous in acute lymphadenitis, though esteemed by many in the chronic. So many surgeons have been inoculated with venereal while operating on suppurating buboes that their misfortune should be borne in mind whenever we expose ourselves to similar dangers—a peril often incurred, as these abscesses frequently require our services.

Constitutional treatment is generally of far less moment than local. It is to be conducted on general and familiar lines, attention being given to the nature and severity of the disease and the state of health of the patient.

Chronic Inflammation of Lymphatic Glands.—This variety of lymphadenitis is commonly insidious in its approach, and may progress to such a degree that a tumor of some size has formed before its presence has attracted the attention either of the patient or his family. It usually is unattended with pain, and after attaining noticeable proportions may remain quiescent for a long period.

It is sometimes a termination of acute inflammation, though generally it originates in some other way. Most frequently the sequence of phenomena is as follows: Somewhere at the periphery of a set of lymph-vessels bacteria obtain an entrance, pass through the tube to the nearest related gland, and establish there a low grade of inflammation by their presence or by toxins which they form, or by both. It is not absolutely proved that in every case the admission of micro-organisms inaugurates the morbid process; but all the probabilities point more strongly in that

direction. The inflammation is rarely more intense than to merit being called subacute, and is often even less vigorous. Gross examination of the node does not disclose the classic phenomena of inflammation. An inflammatory process has been begun, which in a time varying from a few months to many years is destined to destroy the gland, and, possibly, the life of the patient. The most characteristic thing about it is a perverted growth of the connective tissue of the gland, which so encroaches upon the space normally occupied by the cells that they are gradually destroyed or driven out to an extent proportionate to the hypertrophy of the framework structure. A gland may thus become merely a lump of connective tissue. Sometimes, however, there is great increase in size, attended with the development of large cells. The affection of one gland is often followed or accompanied by that of another or many in the vicinity, and the inflamed glands in a group have an aptitude for coalescing into a hard, lobulated mass, which may attain a great bulk, and by its presence cause not only disfigurement, but also severe suffering and interference with the functions of vital organs. The diseased masses are very prone to various degenerations, particularly the caseous. In this process there is destruction of the blood-vessels, cells, and network, all being converted into cheesy material. This may undergo no change for a very long time, or it may soften very rapidly, and, exciting acute inflammation around itself (*periadenitis*), be in part discharged. The remainder acts like a foreign body and prevents healing for a long period. Finally, granulation effects a closure, leaving a scar which is puckered and unsightly.

This variety of lymphadenitis is most common in the poorly-nourished, and especially among those unfortunates who are begotten while one or both parents are afflicted with tuberculosis or with some grade of syphilis which is not of such malignity as to give rise to the congenital form of the disease. The general condition is discussed in a preceding section of this article.

Constitutional **treatment** is always needed. The most valuable of the remedies required are the hygienic—unlimited fresh air, an abundance of the most nourishing and easily-digested food, suitable clothing, frequent baths, judicious exercise, a salubrious climate. Unhappily, only a minute minority of such cases can possibly be provided with these things. The ideal plan breaks down utterly in the presence of penury, and only less completely in that of moderate means. We are obliged, therefore, with medicines alone to undertake a task which is extremely difficult when, in addition to them, there is every other desirable thing which affluence can obtain. Supportives and tonics are always indicated, cod-liver oil and iron holding the places of honor. The effects of arsenic and mercury in small doses are often very beneficial, and iodine in some form has long been recognized as of great value.

When the gland is hard, but never when softening has taken place, good may be done by the application of ointments of iodine, iodoform, and the iodides of lead and potassium, which, well rubbed in, favor the resorption of the abnormally deposited materials. Possibly, the friction with which these unguents are applied is entitled to quite as much credit as are the drugs. Whichever ointment is selected, it should be used

daily until the skin becomes somewhat tender, and then an interval of rest should be allowed until the soreness has disappeared. The tincture of iodine, commonly prescribed in an indiscriminate and routine manner in these affections, is probably of very little value in promoting absorption.

If an abscess forms, it should be opened and the pus evacuated. The incision is better when small, and may well be made with a cautery knife heated to a dull red. Not only is the comfort of the patient promoted and recovery expedited by early incision, but the resulting scar will probably be less noticeable than that which follows spontaneous evacuation.

With the purpose of causing induration of the glands, thus substituting innocent cicatricial tissue for the morbid deposit, which may at any time suffer a degeneration and become a menace to health and life, the injection into the centre of each of some caustic material has been practised with success. Two minims of a 10 per cent. solution of chloride of zinc, introduced with a hypodermic syringe once a week or so, will often bring about the wished-for change. Three minims of equal parts of carbolic acid and glycerin are much esteemed for the same purpose. Puncture with the thermo-cautery is much preferred to injection by some surgeons who have had large observation of both methods.

This disease affects principally the lymphatic nodes of the neck, these being more exposed to the invasions of bacteria, as from various surfaces of the mouth, the nasal passages, and the ear, than are those of the groin and armpit. The injurious effects of a large mass in this locality are more pronounced than if its pressure were applied to any other external part, by as much as the organs in the neck are more essential to life. Consequently, the question of removal by a cutting operation is constantly being raised. Professional opinion is divided on this point: surgeons of great ability and experience deprecate interference, save in a few specially favorable conditions; and others, of equal merit, enthusiastically advocate removal in most cases. The arguments are not based entirely upon the necessity of removing pressure, which is not often serious enough to kill, but much more upon the desire to get rid of masses which we are unable to distinguish from tubercular enlargements, and which we are discovering to be, in most cases, the residence of bacilli tuberculosis. The infection of the whole system from degenerated cervical glands is not common, and yet it may occur in any single case; and this naturally makes us wish that the glands were out, and may lead us to operate when it would be better to leave the patient untouched by the knife. It is a widely-recognized fact that when a mass of cervical glands is only slightly movable it is impossible to tell beforehand how far it dips into the deeper regions of the neck. If only those portions that can be easily reached are removed, little good may come of the procedure, and possibly much harm may be done by it; for there prevails among many surgeons whose judgment is entitled to respect an opinion, which cannot be altogether groundless, to the effect that surgical interference with a mass of tuberculous glands which does not extirpate them is very liable to stimulate those which remain to great activity, so that the tumor in the neck is soon restored to its former volume, and there is as much danger as before that the whole system

will become infected. It is unfortunate that, in the various articles in recent medical literature by those who argue for thorough removal in all cases, so little account is made of the history of the patients after operation. The writers may be entirely correct in their position, but they do not take pains to prove themselves so by giving us information as to the subsequent condition of health, both general and local. Until this is done, and on a large scale, there will be room for the view that the existence of a mass of chronically-inflamed glands, even though tuberculous and undergoing some degeneration, will not necessarily, or even probably, be the starting-point for a general tuberculosis. Observations made long ago seemed to prove it true to a large extent that the so-called scrofulous diseases were mutually antagonistic. This clinical observation loses none of its value by the growth of pathological knowledge, which has required the abandonment of time-honored theories. It is probably a good rule to remove freely movable masses, so that neighboring glands shall not be involved by an extension of inflammation. It is demanded that an effort should be made to remove masses which doubtless dip deeply, if by so doing the peril to the life of the patient can be removed also. Beyond this point the situation is not sufficiently illumined to enable one to speak with full knowledge.

The operation for removal of the glands is generally not difficult where they are freely movable. In other cases it may be formidable and heavily tax the resources of the surgeon. The incisions should be long enough to permit the freest possible inspection of the parts concerned. When the glands are reached the knife would better be laid aside and the remainder of the work done with the fingers, perhaps assisted by blunt instruments. It is often impracticable to remove the tumor in a mass; indeed, there is no good reason for attempting it if the piecemeal method is more expeditious. In operating on the neck the principal danger is that the great vessels will be injured. The internal jugular is not infrequently wounded. If it is merely punctured, a side ligature may sufficiently protect from hemorrhage. It has repeatedly been cut off unwittingly. Being pushed into an abnormal position by the bulging growth behind it, and stretched by the pulling to which the tumor is subjected, it is emptied of its blood, and may easily be mistaken for a band or strip of fascia. The vein, the carotid artery, and the pneumogastric have all been cut in the same patient, and that, too, by a surgeon of great experience and skill, who tells of the case in a report of one thousand operations for the removal of enlarged lymphatics of the neck, with only five deaths.

Hodgkin's Disease and Associated Conditions.

The nomenclature of medicine is far from perfect: at many points it is obscure and misleading; but nowhere does it display a more painful degree of confusion than in relation to the disease which is the subject of this section. The trouble has arisen doubtless, in great part, from the imperfect state of information in the premises, and in some degree, apparently, from the reporting of cases insufficiently observed, but, nevertheless, confidently described as belonging under this head, or, if not conforming exactly to the type, claimed as specimens of a peculiar

and hitherto unmentioned variety so distinct as to be worthy of a new and distinguishing name. The time will come—perhaps before many years—when the whole lot of existing titles will be discarded and a new appellation, based upon demonstrable knowledge, will be adopted to designate the disease. The title chosen for this section is thought to possess the negative merit of conveying no erroneous idea of the disease to which it refers, and the positive one of prolonging the memory of a learned and observant physician who many years ago called the attention of the profession to the affection now to be described.

Once in a while a patient—more frequently a male and young—presents himself for advice on account of the enlargement of glands near the surface, and more commonly in the neck than elsewhere. Examination shows that the growth is not painful or tender; that the glands are discrete and not adherent to the skin; that there is no apparent tendency to suppuration or caseation; that the spleen is somewhat enlarged; and that the general health is beginning to suffer in the direction of asthenia. The patient looks slightly anæmic, and the microscope reveals a little diminution of the normal number of colored corpuscles of the blood, while that of the colorless cells is not affected. Tuberculosis and cancer are easily excluded, and the existence of sarcoma is rendered improbable.

The patient is kept under close observation, and the disease is found to progress in the following manner: The glandular enlargement increases, slowly or rapidly; if the former, the tumor is probably hard—if the latter, it is likely to be soft. Other clusters of lymph-nodes take on the same action, the axillary and inguinal probably preceding those in other parts. There is still no suffering, except that of debility, unless, as is not improbable, there is some fever. The number of leucocytes in the blood remains normal, but there is a marked and increasing scantiness of the colored corpuscles—perhaps no more than a third, or even a quarter, as many as there should be. The pallor of the surface is pronounced; the spleen gets larger and larger; and the movement of the disease is steadily toward the impoverishment of the blood and growth of the lymphatic glands. There is noticeable depression of spirits.

In the course of a year, or perhaps two, bad has gone to worse, until every lymph-node in the body, deep and superficial, is enormously enlarged, and the spleen, too, has grown, but has not kept pace with the glands. There is no formation of abscess or cheesy deposit, or breaking down of any kind, but the separate tumors in the various groups have fused together, and between the different colonies the lymphoid tissue, too scanty to be noticed in health, has attained considerable proportions and serves to link them together. The neck bulges out even with or beyond the perpendiculars of the head; the armpits are crammed to the clavicle; the groins protrude in lumpy masses; in short, wherever there is lymphatic tissue there is enlargement. This not only creates deformity, but causes great distress, partly by pressure on nerves, producing pain, paralysis, and, worse still, perverted respiratory stimulus, and partly by constricting other organs, thus interfering with deglutition, circulation, and motion. The patient dies of exhaustion.

The necropsy shows that the lymphatic glands are more vascular

than normal, and are the seat of a new formation of lymph-tissue, but that this addition has been made without preservation of the normal relations between the constituent parts. If the masses are of the soft variety, the chief increase is in the cellular elements; if of the hard, in the fibrous. Throughout the substance of the spleen are small irregular masses looking very like lumps of suet, and practically identical in structure with the new lymphatic growths. In other viscera there are disseminated lymphatic enlargements.

Let us suppose that the treatment has been confined to attention to hygiene and the administration of supporting and comforting agents, none of which can possibly be supposed to have had any effect in aggravating the disease, or can reasonably be credited with the slightest influence in hindering the fatal termination. We have, then, before us a brief clinical history and post-mortem report of a case which anybody tolerably familiar with the literature of the subject would probably admit to be a typical and pronounced example of Hodgkin's disease. That typical cases constitute a majority is not stated or thought, but that continual reference to the type-form for purposes of comparison is helpful in practical clinical work is confidently believed.

The variations from this model are numerous, and sometimes so great as to give color to a suspicion that we have to deal with diseases which, though kindred to the type, are not mere modifications of it.

The most common (alleged) variety is that in which, instead of a substantial preservation of the number of the colorless corpuscles of the blood, there is a veritable leucocythæmia—not merely a relative, but an absolute, increase in the number of the white cells. This has often been considered a factor of sufficient importance to justify the addition of a new name to the nosology in designation of a separate disease. Such a proceeding would seem to be uncalled for in the light of present pathology. The splenic enlargement is usually due to an increase, not of the pulp, but of the lymphatic constituents, notably the Malpighian bodies. But it sometimes happens that, in addition to this commoner and more characteristic overgrowth, there is an augmentation of the splenic pulp; and it is in these cases that the leucocythæmia, which depends upon the change in the pulp, occurs. In other words, we have coincidently two affections mixed in the same person—Hodgkin's disease, with its destruction of the red corpuscles, and splenic leucocythæmia, with its excessive contribution of the white corpuscles. Furthermore, whenever the glandular hyperplasia is of the soft variety it is probable that there is a regular escape of superfluous leucocytes from the glands into the general circulation; and there is thus another reason for this especial disturbance of the typical equilibrium.

A very marked deviation from the pattern is that in which there is no splenic enlargement. This is said to happen in one-fifth of the cases. In other respects these present no variation.

Occasionally the glandular enlargement, instead of beginning in nodes which are accessible, starts in those which are altogether out of reach. This circumstance renders positive diagnosis much more difficult, and sometimes even impossible until external tumors appear; for the mesenteric glands are rarely much affected, and it is easy to perceive

that the bronchial and other thoracic glands may be prodigiously enlarged without our being able to prove the fact.

The alimentary canal may be structurally invaded to an extraordinary degree. The mucous membrane of the stomach has been found studded with cream-colored, flattened tumors, and the colon at the same time containing fleshy nodules of a medullary appearance. The solitary and agminated glands may be vastly swollen, looking like great fleshy plates on the mucous surface.

Great variations of appetite occur. It may be good all through the illness, and is occasionally phenomenal. On the other hand, it is not uncommon to observe anorexia. The bowels may be regular even in cases where the intestines are in a wretched plight organically.

The temperature may be normal, but is usually elevated at some part of every day after the constitution has begun to show signs of distress. The pyrexia varies greatly. Rarely *purpura hæmorrhagica* is associated with the disease.

The **cause** is rarely detected. As the glandular trouble commonly begins in the neck, any source of irritation in the parts of the surface which send lymph to the cervical nodes may well be accused of the offence; but it must be confessed that in the great majority of cases we are unable to discover anything which can reasonably be regarded as the cause of the malady.

The **diagnosis** cannot be made until the tumor is manifest. As has been remarked, leucocythæmia may coexist, and this makes the problem more perplexing. But we are aided by remembering that the glandular enlargement is the primary symptom in Hodgkin's disease, and that the anæmia is rarely conspicuous until somewhat later; whereas in leucocythæmia anæmia is the first thing which attracts attention. In Hodgkin's disease the first enlargement is almost always that of the cervical glands; in leucocythæmia, that of the spleen. The fact that cancer very exceptionally begins in lymph-nodes, being in them almost invariably a secondary deposit, is the principal means of eliminating it in making the diagnosis. When the lymphatic glands are the seat of tubercular deposit, there is a decided tendency to degeneration and the formation of pus. They are also very prone to early agglutination to each other, and grow but slowly. None of these circumstances obtain in Hodgkin's disease. To diagnosticate this disease from sarcoma is most difficult of all. *Lympho-sarcoma* is the name applied to Hodgkin's disease by some writers, and we are not surprised that they declare that the discrimination cannot be made. However, others attempt it, and Winniwarter says that the essential difference lies in the fact that the process in Hodgkin's disease is hyperplastic, "while such tumors only are to be regarded as sarcomatous as in type have nothing in common with the mother tissue." Evidently, the diagnosis requires the abstraction of a portion of the morbid growth for microscopic examination, and this can be done readily by the aid of Mixter's ingenious punch. It is possible that our recently-acquired knowledge of the varieties of leucocytes will enable us to make an early diagnosis by a microscopical examination of the blood; but the whole subject needs to be studied afresh from this point of view, and, as the disease is not common, much time must elapse before we can attain this degree of skill.

The **prognosis** is always grave, and unless the reports of cures by the use of drugs come from men of known capacity, experience, and caution they are to be received with judicial reserve.

Concerning the value of medicines in **treatment**, it may be stated that the most of those which have been tried seem to be utterly worthless. Iodine in any form does no good. Phosphorus has been used extensively, and probably has always failed to give help of any kind. Arsenic is the only drug which at present seems to offer the faintest hope of cure. Competent and eminent observers mention decrease in the size of the tumors under its use, and a few cases of complete cure are recorded. In cases where an operation is not advisable it should certainly be given a trial. It must be administered in as large doses as the patient can endure without producing toxic effects.

Supporting measures of every kind should be employed, not with any expectation of a specific influence upon the disease, but for their effect upon the general system.

Injection of the tumors has not been so successful as to call for detailed description. Massage, compression, and blistering have been recommended, but it is not obvious in what manner they can do good.

To the surgical mind the question of operation inevitably presents itself. If the disease has reached the stage of general implication of the glands, the knife is warranted only for the purpose of removing such masses as cause great suffering by their pressure; and it should be used with the distinct understanding of all concerned that the only object in view is the temporary comfort, and not the cure, of the patient. But where only a single and accessible group of glands is involved, the spleen not enlarged, and the anæmia insignificant, operation is justifiable, and even to be recommended; for, while it may do no good, it gives the patient the chance of benefit possibly resulting from the extirpation of a tumor which, allowed to remain, may cause the infection of the entire system. Some reported cases seem to have been cured by operation performed in these circumstances. The value of many of the reports of cures by cutting operations is quite destroyed when we consider that their authors have announced their successes within a few weeks of the ablation of the glands. Such reports have no bearing on the curability of the disease: they simply certify to the removability of the visible mass and the healing capacity of the patient—they are merely testimony on points which needed no proof. One thing may be stated about the operation with positiveness: it must be complete or it will be fruitless. It may be very easy or appallingly difficult. The use of the digits is preferable to that of the knife as soon as the capsule has been incised.

It is perhaps proper that a reason should be given for the disparaging remarks on the terminology which has grown up around this malady, including lymphadenoma, generalized lymphadenoma, lymphadenosis, lymphoma, adeno-lymphoma, malignant lymphoma, infective lymphoma, adenia, adenosis, progressive glandular hypertrophy, hyperplasia of lymph-nodes, lympho-sarcoma, multiple sarcoma, lymphatic anæmia, splenic anæmia, pseudo-leucocythæmia, pseudo-leukæmia.

If each of these terms was employed merely as a synonym for Hodgkin's disease, the only objection to the collection would be that it is

superfluous, and to various individual members of the group that they convey an incorrect idea of the disease which they were evidently intended to characterize in a word or two. But a number of them are used also to designate some other malady, and, consequently, it is impossible to know what is meant when such a term is employed. It seems judicious to ignore all of them, and when our knowledge becomes sufficiently precise we can agree upon a concise descriptive name to designate the disease.

DISEASES AND INJURIES OF THE HEAD.

By ROSWELL PARK, M. D.

Erysipelas of the Scalp.

Erysipelas of the scalp is for the most part an extension of similar lesions of the face and neck. Nevertheless, it may attack the region of wounds or it may accompany deep suppurations. Scalp wounds seem to be followed by it more often than those of any other part of the body; which is to be partly explained by the readiness with which infection occurs along the hair-follicles and sweat-glands, as well as from the fact that a perfectly clean scalp is a comparative rarity. Blebs seldom form about the hairy scalp, but are frequent about the forehead and ears. The hairs frequently fall out, but are almost invariably replaced by a copious new growth. Erysipelas of the scalp has been regarded as always serious, rather on account of the complications which frequently accompany or follow it. The most serious of these are infections of the brain or the underlying membranes. Sympathetic involvement of these may be manifested by various degrees of severity, varying from slight delirium, which is usually rather symptomatic, to the most active infection of fulminating rapidity. As a rule, they occur during the period of pyrexia, and usually subside with the fall of temperature. Brain-symptoms, of course in mild degree, may exist as the result of fever and toxæmia, or may be produced by irritation, which frequently causes lesions along the course of the cranial nerves. True meningitis usually does not occur until the erysipelas has completely declared itself. It will be dealt with at greater length farther on. It is a condition very frequently fatal. Under these circumstances pus is usually found on post-mortem examination, and the erysipelas may be regarded as having assumed the phlegmonous type. This, of course, can only be regarded as a direct extension of the infectious process. If this can extend itself to the subcutaneous tissues, to the parotid, or to other localities, it may also to the meninges as well. The facts are, that the path of infection is largely along the openings for the emissary veins and the nerve-sheaths. When erysipelas results from a wound, there is usually laceration of the scalp and discharge, which becomes more or less offensive, while the wound itself takes on a diphtheritic aspect, with more or less tissue-destruction, and even sloughing down to the bone; along with which may go extensive thrombosis in the external or internal veins. Naturally, when the dura is exposed by the wounds in question the possibility of infection is much easier. Sometimes deep suppuration seems

to be produced, not so much by the infection itself as indirectly by the disturbance consequent thereupon; and so abscesses may form in the orbit, about the cavernous sinus, or elsewhere inside the cranium. Lebert once found a collection of pus in the frontal sinus under the same circumstances. Much more frequently we meet with subcutaneous abscesses, especially about the orbit and in the upper eyelid. Unless these be speedily incised we may have gangrene of the overlying skin and resulting ectropion. So, too, we may have multiple abscesses of the scalp, meeting with them particularly behind the ears and down the neck. Disturbances of sight and hearing are the occasional results of this disease; in mild forms they are often observed, and we occasionally have more pronounced lesions, even complete amaurosis. For the most part, however, these disturbances are caused by œdematous infiltrations about the orbit or nerves, and subside with the subsidence of the general disturbance.[1]

Cellulitis of the Scalp.

Both acute and chronic cellulitis occur in and about the scalp. Both are, for the most part, results of suppuration or of phlegmonous lesions, although in the chronic form the lesions may take on the characteristics of a cold abscess. Acute phlegmons of the scalp frequently result from injury with coincident infection. For the most part, they are the result of phlegmonous erysipelas, as the result of which one may have very extensive infiltration and more or less sloughing or destruction of the scalp. This is more frequently the case when the presence of pus is not easily recognized and when it is not evacuated. Almstrom, for instance, has reported the case of a middle-aged man in whom the entire scalp was involved in a fluctuating tumor, which opened behind the right ear as the result of gangrene at that point, and from which there was discharged a most offensive bloody fluid: death resulted from pyæmia, and upon autopsy the entire neck and back were found undermined with pus.[2]

In these cases the principal danger is from purulent collection, intracranial infection, or general sepsis, which usually takes the form of pyæmia; in fact, most of these cases do die of pyæmia, the result of a sinus-phlebitis or of meningitis. Circumscribed abscesses upon the scalp are of much less importance. Chronic abscesses are found most often in marasmic children or in tubercular and syphilitic cases, particularly during the first two years of life. These collections are sometimes even subperiosteal, in which case there is often infection of the underlying bone. Multiple abscesses are not infrequent, and are met with most often behind the ear, sometimes upon the forehead, and sometimes along with cold abscesses in other parts of the body. A history of injury accompanies some cases, while others appear to have originated spontaneously. In the former the traumatism is seldom severe, only enough to cause small hemorrhages, which are found to be the starting-point of the subsequent lesions, particularly in predisposed individuals.

[1] *Vide* Gloor, "Beitrag zur pathologischen Anatomie der Orbital phlegmone," *Ziegler's Beiträge zur path. Anat.*, xvi. p. 408, 1894 (bibliography attached).

[2] *Ups. Läk. Fören Förhand.*, xi. p. 382.

It is usually sufficient to incise these, especially when they occur behind the ear, since in most instances it will be found that the periosteum will quickly apply itself to the bare bone and that healing will be speedy.

Carbuncles.

Carbuncles seldom occur upon the scalp proper, although they frequently appear upon the back of the neck and then encroach upon the regions above. Even the ordinary small carbuncle is seldom found upon the scalp. Nevertheless, carbuncles have been known to extend around from one ear to the other. Under these circumstances the infection is most serious and prognosis most unfavorable. Oberst once saw an ordinary carbuncle upon the back of the head prove fatal in ten days from septicæmia, and Helferich has seen death result from a carbuncle of the temporal region. This is an essential corroboration of the clinical evidence regarding the fatality of carbuncles about the face and head; the explanation of which is usually the occurrence of phlebitis and pyæmia by the medium of the diploëtic veins. It is possible to abate in some instances a commencing lesion of this kind by the application of caustic pyrozone, but after such a lesion is completely declared it is best treated by early and free incision, with excision of all infected tissues, accompanied by curetting and cauterization of the local foci with zinc chloride.

It should suffice in this place to simply call attention to the fact that carbuncles here or anywhere else are usually expressions of toxic conditions, such as are met with in diabetes, pronounced uric-acid diathesis, alcoholic patients, etc., and that simple local treatment is not enough, but that most energetic measures should be directed toward the constitutional condition as well.

Gangrene of the Scalp.

This may be the result either of injury or of acute inflammation. It occurs more often in badly-nourished children than in any other class of patients, and has been known to follow acute forms of intertrigo, eczema, and impetigo. In one such case gangrene extended from the side of the face down to the neck. The possibility of gangrene due to special and unusual forms of infection must not be overlooked—such, for instance, as that known ordinarily as "gangrenous emphysema" or "gangréne foudroyante." Gangrene may be followed by caries of the underlying bone, and it is on record that even a caput succedaneum has been followed by necrosis of the skull. In well-marked cases of gangrene of the scalp the disturbances are usually such that the prognosis is bad. Should it threaten, it would be well to cut away the suspicious area, to cauterize, and to use antiseptics freely and abundantly, combating at the same time the accompanying prostration of the constitutional condition which permits such tissue-death. Gangrene is necessarily a more or less prominent part of carbuncle and of some of the phlegmonous lesions above referred to, and its treatment then is part of that pertaining to those lesions.

Ulcerations of the Scalp.

Ulcerations of the scalp may result from wounds, from destruction by carbuncles or phlegmons, or from acute inflammations and their consecutive lesions. Spontaneously, ulcerations in this region are, for the most part, of syphilitic, tuberculous, or cancerous nature. Lupus of the scalp is known, although very rare except as an extension from similar trouble of the face. Lupoid ulcerations of the temporal and orbital regions may lead to such cicatricial contraction of the lids as to cause serious defects. In fact, the same may be said concerning the ear or other parts of the head. The most common ulcerations of the scalp are those due to the breaking down of neoplasms. These may be cysts, particularly the atheromatous forms, or the lesions may belong to the infectious granulomata or to tumors proper. Ulcerations of follicular cysts due to inflammatory and infectious conditions may resemble those above referred to—to such an extent that some care is required in differential diagnosis. In such a case a careful study of the history will be required.

The **treatment** for all these conditions is essentially that suitable for similar conditions in other parts of the body.

Gaseous Tumors of the Scalp.

EMPHYSEMA.

As we may have general emphysema of the surrounding parts after injury to the larynx, trachea, or lungs, so from lesions of the upper air-tract we may have a diffuse or circumscribed emphysema of the scalp; nevertheless, it is not frequent. The most frequent causes of this condition are fractures involving the nasal bones, the pharynx, or the ethmoid. When either of these occur, the air may be blown through the fissures into the subcutaneous cellular tissue. When met with, emphysema of the scalp may be valuable as a diagnostic feature concerning some unseen fracture within. It is possible also that it may occur as a result of basilar fractures extending into the middle ear and connecting with the Eustachian tube. Leduard has reported a case of a young girl whose temporal bone was penetrated by the point of a scythe. Along with unconsciousness, vomiting, and delirium, she exhibited an emphysematous condition extending over the entire side of the neck. She died on the day following the injury, and examination showed penetration of the bone and injury to the brain. Schmidt has described emphysema of the mastoid region as a result of forcible inflation of air by the Valsalva and Politzer methods of inflating the middle ear. It is also possible to blow in air through and from small external wounds, and Fabricius Hildanus has related the case of a child whose parents were accustomed to thus produce emphysema of the head in order to exhibit the patient for money.

So far as the **treatment** of the condition is concerned, it should consist of enlarging the external wound, should there be one, in order to allow the air to escape, or it may possibly justify puncture in cases where there is no external lesion. Ordinarily, however, these puffy swellings disappear spontaneously, the air being absorbed by the blood

circulating through the part.[1] Should there, however, be a distention by gases of putrefaction, as is possible in certain infections of the deeper tissues by gas-forming bacteria, then free incision, with the generous use of antiseptics, should be promptly resorted to.

PNEUMATOCELE.

Of the greatest importance in this connection are those rarer conditions of chronic gaseous tumors which have been known under the name of "pneumatocele." These consist for the most part of cavities continuously distended by air which escapes from the cells of the underlying bone, situated for the most part under the periosteum, and constituting, as it were, cysts whose contents are air and not fluid, and which are bounded on the outside by the soft parts. Most of them are met with about the region of the mastoid process; a few have been recognized about the frontal sinus. Of the former, at least ten cases are met with in literature, of which the one published by Wernher has been, perhaps, the most widely reported. This concerns a young man of twenty, who four years previously, after sneezing violently, suddenly discovered a tumor behind the right ear, which became smaller upon pressure, to soon reappear. It grew slowly, and became finally as large as a fist, and was not influenced by pressure; around its base was developed an area of thickened bone. Upon percussion it was sonorous, and upon violent expiration with the closed mouth and nose it became a little larger and more blown up.[2]

The consistency of these tumors is soft and elastic. Sometimes, upon auscultation, one may hear sounds as of the passage of air, while upon percussion they are very resonant. Usually about their bases there is a thickened margin of bone, and it seems as if either the external table were lifted up or as if new bone had formed around the margin. In one recorded case there could be felt through the tumor a fragment of the mastoid process. A few patients have complained of headache or of cranial discomfort. In one case of Lloyd's, dizziness, vomiting, numbness of the arm, and partial paresis of the same were complained of. Hearing seems never to have been affected in the recorded cases.

The causes of these pneumatoceles are to be found in the existence of defects, usually of the outer bony wall of the mastoid cells. Through these openings air may be forced through the middle ear by violent effort—as, for example, sneezing—and escape under the pericranium, which is thus forced away from the bone. This process, repeated at short intervals, leads to the gradual development of a tumor of considerable size. The air thus forced in comes in contact with the pericranium as well as the bone, and there is almost always proliferation of the latter at the point where it is separated from its covering. Here the tumor itself grows, as does the covering to the portion separated, while new formation goes on; and so these tumors seem to rest upon a firm, thickened, bony base, which will account for the bony prominence spoken of in the case above briefly referred to and in others. These are purely

[1] *Vide* also Marcus, "Ueber das Emphysem des Orbita," *Deutsche Zeitschft. f. Chirurgie*, xxiii. 169.

[2] *Deutsche Zeitschft. f. Chir.*, 1873, iii. p. 381.

secondary formations, explainable in the way just mentioned. The existence of the tumors is another evidence of the ease with which the pericranium can be stripped from the bone, except along the line of sutures and at a few other points.

The bony defects which permit the occurrence of pneumatoceles may be either congenital or acquired. Kirchner[1] investigated 300 adults, and found in about 25 per cent. of the cases some slight defect in the squamoso-mastoid fissure, either on one side or on both. Kiesselbach[2] investigated 174 skulls of individuals from one to nineteen years of age, and found 4 per cent. of widely-open squamoso-mastoid fissures, and that in 45 per cent. there were larger or smaller defects in its absolute closure. Equally or more important are the relatively common defects in the external walls of the mastoid cells, particularly at points where vessels pass through.

These defects in ossification have been described by numerous writers. That pneumatoceles resulting from such defects have been mostly noted in adults, and not in children, is to be explained by the relative inability in children to make severe expiratory efforts.

Diagnosis is not difficult, because of the peculiar elasticity of the tumors, their resonance on percussion, and the possibility of influencing them more or less by continuous pressure, sometimes with the accompaniment of a blowing sound as the air escapes from the middle ear. Should there be doubt in any given case, it may be readily solved by simple puncture.

In the way of **treatment** puncture has been resorted to by some, incision by others; but the best results in the treatment of these tumors have been achieved by the combination of puncture with the injection of a little iodine solution. Sonnenburg has reported one success after radical operation.[3]

Pneumatocele of the frontal region, or "pneumatocele sincipitalis," as distinguished from "occipitalis," is still rarer. Up to 1882 only five cases had been reported, which were for the most part of small extent and found near the middle line. In a case reported by Warren the tumor was divided, as it were, into two by the middle line of the forehead. There has been noted in these cases less bony proliferation; they have been shown to have the same tendency to be inflated by violent expiration and to be reduced by pressure, while escape of air could be heard at the root of the nose. Communication was noted with the frontal sinus in 3 cases, resulting from injury; in the other 2 the lesion was due to violent and destructive inflammation. Only 2 of these cases were subjected to treatment: one was healed by continual compression, and the other by incision, although a fistula of the frontal sinus remained.[4]

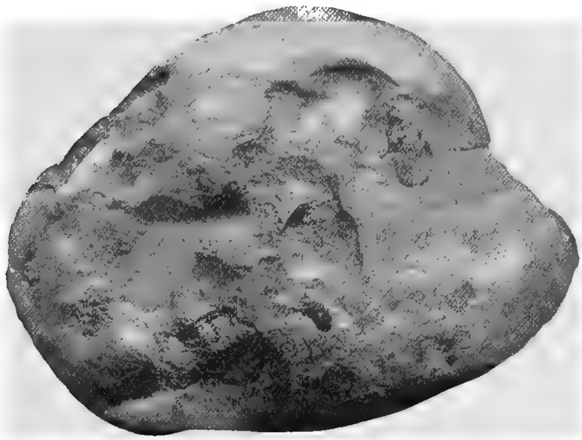
Syphilis of the Scalp and Cranium.

The scalp is perhaps as often as any other part of the body the site of superficial syphilitic lesions. Those most often met with belong to the papular, squamous, and vesicular forms of syphilides. The integu-

[1] *Arch. f. Ohrenheilk.*, 1879, xiv. 190. [2] *Ibid.*, vol. xv. 238.
[3] *Deutsche med. Wochenschft.*, 1889, p. 533.
[4] Vide also Heineke, *Die Chirurgischen Krankh. des Kopfes*, 1882, pp. 10 et seq.

ment of the forehead is most frequently attacked of all; it breaks down easily, and one commonly looks for superficial evidences of syphilis at the border of the hair-line. Here also occur the semilunar or circular arrangement of eruptions, as well as those lesions described under the

FIG. 382.



Syphilis of cranial bones (Wood Museum).

tubercle or gummatous forms which lead to ulceration, sometimes of destructive type. The deeper layers of the scalp rarely exhibit syphilitic defect. When this occurs it includes for the most part gummatous lesions, which quickly break down and result in ulceration. In the subcutaneous connective tissue one observes occasionally nodules which grow to the size of cherries, and which sometimes become so suppurated as to resemble small abscesses: after a little the overlying skin becomes red and thin, and then gives way, permitting the escape of a puruloid fluid. These lesions do not always proceed so far, but sometimes retract and leave small white subcutaneous cicatrices. These nodules often arrange themselves in semilunar forms, and sometimes form ulcers of this general shape.

Syphilitic defects of the external table consist, for the most part, of deep gummata, and belong among the later manifestations of the constitutional disease. They are met with more often about the orbit and temporal bones, and frequently involve the orbital plates. Some of these lesions may proceed from the depths of the bone and constitute an intracranitis syphilitica. The external forms sometimes assume the type of ossifying periostitis and spread over a large extent of bone. The osteophyte of syphilitic origin is usually firm and thick; sometimes circumscribed, at other times diffuse. Another form, met with occasionally, is known as "pericranitis gummosa," and is characterized by this: that between the periosteum and the bone there forms a gumma, which is later followed by a variety of changes in the bone itself. These tumors are small and are frequently grown together, and the pericranium is thickened in that vicinity. They are prone to break down or to form

caseous masses. They may be separated with the periosteum when it is stripped away from the bone. They lie sometimes in small depressions into which open vascular canals. Into these latter the gummata extend themselves sometimes, so that where the periosteum is torn off they leave behind small processes projecting into the cranial openings. Such gum-

Fig. 383.

Syphilis of cranium from a prehistoric skull (U. S. A. Museum, No. 90).

mata are capable of spontaneous resorption. A true gummatous ostitis often begins in the diploë, and the gumma itself often has its origin in the marrow-tissue, and forms a tumor which leads to subsequent absorption and disappearance of bone through the entire thickness of the skull; as the result of which we may have multiple perforations. At other times the foci in the diploë may be so numerous and diffuse that we seem to have a case of gummatous involvement of the entire spongy structure.

Besides the gummatous formations of endocranitis, we have also finally the simple or adhesive cranitis, which is characterized by extensive vascularization of the dura, the vessels becoming very numerous and penetrating into, or even through, the porous bone. Now the dura becomes more adherent, and, when stripped off, the vascular openings representing the torn vessels exhibit numerous annexes to the dura mater.

When the dura is involved it is usually from the outer surface. There is a specific form of pachymeningitis gummosa. The usual small tumors make room for those either in the bone or encroaching upon the cavity of the skull. It is quite possible for these tumors to assume considerable size and to produce brain-symptoms from pressure, without

reference to accompanying conditions. The brain suffers, apparently, less from the pressure of these tumors than from the attack upon the pia or on the nerve-substance itself. Gummata appearing upon the inner surface of the dura are adherent to the pia and usually to the cortex. They, for the most part, undergo a dry caseous degeneration, and spontaneous resorption is possible through the agency of minute fatty changes. Upon the inner surface of the dura, both in cases of endocranitis and pachymeningitis, we have to do with hemorrhagic pseudomembranes. It is also possible that the sheaths of the nerves may be involved in the same changes. This is most frequently the case with the optic nerves and with the motor nerves of the eyes. In most cases of syphilis of the brain or membranes we find also more or less characteristic changes in the bones of the skull. In hereditary syphilis all these affections are more rare, and when met with are commonly of the pachymeningeal character, including a firmly adherent dura with early gummatous lesions.

So far as **symptoms** are concerned, aside from local appearances, they consist in large measure of pain, which is almost always worse at night. Other symptoms are either those of pressure or of inflammation of cranial nerves or paralysis of the same. So soon as these lesions begin to break down or to suppurate the clinical picture of the disease is either changed into, or constitutes, a picture of caries with fistulous openings, external ulcerations, etc.

The **course** of syphilitic defects of the head is chronic and may extend over years. When it has once occurred, it is a very difficult matter to ensure the patient good health, no matter how active the treatment may be. In many cases the suppuration which follows meningitis leads to entire degeneration, and then to a chronic marasmus with following death. A true active or acute syphilitic meningitis or encephalitis is very rare. It, of course, may cause death, or death may result indirectly from pressure or from localized paralyses and their consequences.

Tumors of the Scalp.[1]

Although the scalp is by no means exempt from most of the tumors which involve the other parts of the body, there are a few which most deserve our consideration. It should be enough here to remind that lipomata are rare about the scalp;[2] that fibromata are not very often met with, and involve usually the periosteum; that osteomata, chondromata, and mixed forms of similar tumors occasionally involve the periosteum and the bone; but that the tumors which particularly interest us are those of congenital origin cysts and the malignant tumors.

Of tumors of dermoid or congenital origin involving the scalp or the skull, we shall call attention particularly to the following:

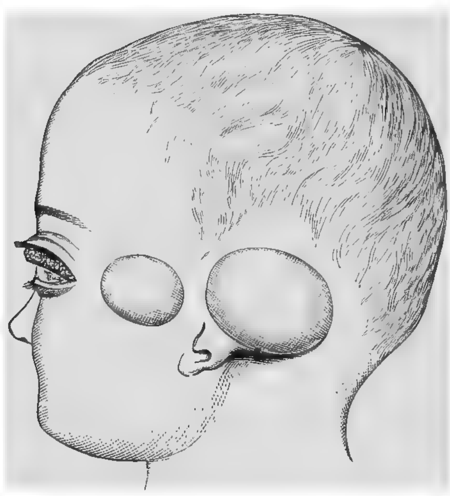
The most common by all means of the scalp-tumors are the so-called "atheromatous cysts," whose etiology of course is well known, and for discussion of which we refer to the article on Tumors. These consti-

[1] Wassermann, "Zur Statistik der Bindegewebstumoren des Kopfes," *Deutsche Zeitschft. f. Chirurgie*, xxv. 368.
[2] *Vide* Fieber, "Ein seltener Fall v. Lipoma fibrosum am Kopfe," *Ibid.*, xii. 112.

tute the so-called "wen," and may be found single or multiple, in size varying from the slightest enlargement up to tumors as large as the fist. When these tumors attain a size so that the duct is stretched more or less open, it is very common for air-infection to take place and putrefactive changes to be set up within the contents of the cyst. Under these circumstances inflammation soon follows, and we frequently see a complication of inflamed and suppurating atheromatous cysts, the discharge from which is extremely offensive; in fact, I scarcely know of any material with which the surgeon has to deal which is more unpleasant to handle or to cope with than the contents of some of these tumors. The odor is peculiarly offensive, and clings about the hands for a long time unless mustard be used for their disinfection.

The **treatment** in all these cases is complete extirpation, and when the parts are thoroughly infected or inflamed it would be bad policy to endeavor to get primary union by close apposition, or to take any other course than to disinfect the parts thoroughly—for which purpose hydrogen peroxide answers fairly well—and then to treat them openly; or if there be a cavity, it may be packed with gauze and secondary sutures inserted, to be re-dressed on the second or third day.

FIG. 384.



Dermoid cysts of malar and post-temporal regions (Lannelongue).

The *dermoid* tumors of the scalp awaken our interest, not so much because of their rarity as because of their embryological interest. Observations concerning the occurrence of cysts resembling ordinary dermoids were made among the first by J. C. Langenbeck, and by Lebert in his treatise on Dermoid Cysts, published in 1852. Isolated instances had been previously reported by Fabricius Hildanus, by Morgagni, and by Ruysch. Perhaps the first man to recognize them as true dermoids was Leblanc.[1] Close attention to the frequency of their occurrence about the orbit, the root of the nose, the glabella, the large fonta-

[1] *Journ. de Méd. vétérinaire*, 1821, p. 23.

nelles, and perhaps even about the mastoid, has been given by subsequent writers.[1] These tumors vary in size from that of a pea to that of a fist; those smaller than a pea are seldom discovered.[2]

Most of the references to this subject are found in very recent litera-

Fig. 385.

Congenital cyst of temporal region and dermoid of cornea (Lannelongue—*Kystes congénitaux*).

ture. In that published up to 1876, Mikulicz only found 12 such cases, to which, up to 1890, 8 more had been added; so that up to that date there were altogether only 20 cases of dermoid cysts of the large fontanelles on record, to which Cohen, who collected the above cases, added another which he had observed in the Erlangen Clinic.[3] Cohen has called attention to the fact that the structure of these tumors is very similar to that of the skin, and that, for the most part, they consist of epidermal cells with other degeneration-products. Nucleated epithelial cells are produced from the cyst-wall; they vary very much in size, and of course at the beginning are very small. They vary also in rapidity of growth. In one case of Textor's the tumor, which was scarcely visible at first, had reached the size of a goose-egg when the patient was ten years old; in the case reported by Fehleisen the tumor was noticed when the boy was ten years old, and gradually grew. At the end of fifteen months it had spread out underneath the skin, and brain-symptoms were added to the other condition; brain-substance could be felt through the tumor. Two years later it was examined by Bergmann, and just about as an operation was to be performed it began to shrink and retracted to about one-half its previous size, when the changes seemed to cease. Such spontaneous absorption of the fluid contained in dermoids is certainly rare. Severe

[1] See Hewett's "Contribution to Surgery of the Head," *St. George's Hos. Reports*, 1869.

[2] *Zur Diagnostik und Casuistik der Epikraniellen Dermoidcysten*, by Edward Rathlef, Dorpat, 1876; Wernher, "Cysten der grossen Fontanelle aus abgeschürten Meningo-enceph. enstanden," *Deutsche Zeitschft. f. Chir.*, viii. p. 506.

[3] *Dermoid-cysten der Grossen Fontanellen.*

inflammatory symptoms have been observed in them, notably in one case of Ollier's. These tumors are usually round or spherical, permit the scalp to be moved over them, are sharply circumscribed, and are not movable on the underlying bone. By some they have been believed to exercise an influence on the development of the bone by which it seems to be arrested in growth. For the most part they have been mistaken for meningoceles, rarely for encephaloceles.

Differential **diagnosis** is not always easy without operation, or at least puncture. They are to be differentiated by the rarity of the truly cystic condition; by the fact that the meningoceles can be influenced by pressure, their blood disappearing; by the fact that dermoids, having thicker walls and their contents being more or less solid, are much less likely to fluctuate than are meningoceles; and, finally, by the fact that they never diminish in size during sleep.

These dermoids may also need to be distinguished from herniæ cerebri.[1] Dermoids can rarely, if ever, be pressed back within the cavity of the skull. Meningoceles rarely occur exactly in the middle line except in the occipital region. The same may be said of hernia cerebri, which rarely appears through the sagittal suture, but through the large fontanelles. Very few cases indeed are recorded like those of Meckel and Held, where the great fontanelle was found open in grown-up patients, and where an encephalocele protruded through this congenital defect.[2]

A case has recently come up in my own practice of a tumor appearing in the temporal region, diagnosed as atheromatous cyst. It was attacked, the outer portion being removed, but recurred along with exophthalmos. I made a diagnosis of dermoid within the orbit, and had to make a rather serious operation, by which a minute connection was found between the external sac and the balance of the same within the orbit. In this latter compartment, which was as large as a cherry, was found a quantity of hair and other dermoid products. The patient made a speedy recovery.

Concerning their **treatment**, there seems to be no good reason why, if aseptic precautions can be carried out, they should not be extirpated. The very fact that connection between the cysts and the brain-cavity is not present appears to be a strong recommendation in favor of extirpation. The sac-wall may be either completely extirpated, or so much of it as shows any access to the cavity of the cranium may be left for protection. Injection methods of causing obliteration are in reality much more dangerous than attempts at radical cure.

Another form of scalp-tumor of not very rare occurrence is the so-called "cornu cutaneum" (Fig. 386). This is a veritable cutaneous horn formed by circumscribed hypertrophy of the epidermis, and consisting of an outgrowth of horny consistency and appearance and of variable size and shape. These horns are usually tapering, may be either straight or curved, and occasionally are completely bent upon themselves. Sometimes they assume flattened forms; at other times they are but slightly elevated. In color they are of a dirty, grayish-yellow appearance,

[1] See also Spring, *Monograph de la Hernie du Cerveau*, etc., Bruxelles, 1853.

[2] Vide Heineke, *Chirurg. Krankh. des Kopfes*, 1882, pp. 147 et seq.; also Lannelongue, *Traité des Kystes congénitaux*, Paris, 1886; *Affections congénitales*, Paris, 1891, vol. i.; and Fehleisen, "Zur Diagnostik der Dermoide des Schädels," *Deutsche Zeitschft. f. Chirurgie*, xiv. 5.

although when old and exposed to accumulations of dirt from outside sources they may be found almost black. Their surface is rough, irregular, more or less fissured, and the ends may have various shapes. As a rule, the horn scarcely ever is more than a half an inch in diameter at the base, which latter rests directly upon the skin. The adjacent tissues

FIG. 386.

Cornu cutaneum (Wood Museum).

are usually normal, there being an abrupt transition from healthy skin to the base of the outgrowth. Sometimes, however, large papillæ are found in the neighborhood. They are for the most part solitary; still, multiple horns have been recorded. In a case recorded by Batge[1] the whole lower part of the body was studded with these growths. While they may occur elsewhere, they are by all means most common upon the scalp and face. They usually occur late in life, but have been observed in the young. They are hard, dry, more or less brittle; are rarely painful, except when disturbed. They are slow in growth, and frequently loosen and drop off, but are almost always reproduced. They seldom disappear spontaneously. They bear close resemblance to warts, and, in fact, are essentially hypertrophic warts. As in the case of nearly all cutaneous outgrowths, they may be followed by epitheliomatous degeneration.

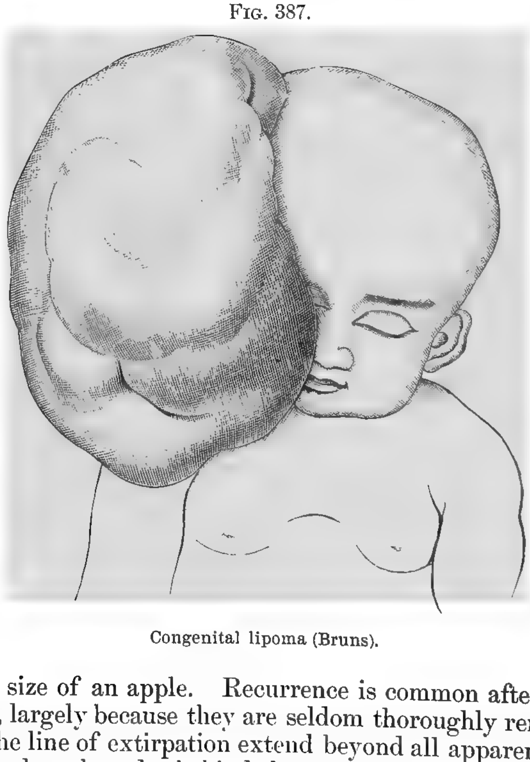
The only satisfactory **treatment** for these growths is complete excision of the entire mass, with extirpation of the area from which they grow, including the periosteum.

[1] See *Deutsch. Zeit. f. Chir.*, vol. vi. p. 474, 1876.

Carcinomata.

True cancer not infrequently springs from the coverings of the skull. Gurlt collected 163 cases of tumors of the head and scalp, among which were 44 carcinomata. Of 675 carcinomata of the skin observed during twenty-seven years in the Dorpat Clinic, 33 times the coverings of the scalp were involved. Of 526 cases of cancer observed in Erlangen during twelve years, the scalp was involved in 34 cases. These tumors seem to be most common in the frontal and temporal regions. For the most part, carcinomata in these regions assume the form of rodent ulcer or epithelial cancer. Other varieties, however, are not unknown. They are met with more often in men than in women, and usually in those of advanced years. Lossen observed, however, a carcinoma in the forehead of a girl eighteen years of age, which seemed to have proceeded from acne. Cases are not rare in which ulcerating atheroma seems to have been the primary lesion. Many of these tumors are very extensive. Valeriani observed one which reached from one mastoid over the scalp to the other. Bartholomi observed another extending from the temple to the middle of the neck posteriorly. Many of them involve the underlying bone, and when the disease goes on long enough even the underlying dura is involved. In a case of Koenig, in 1682, of cancerous ulcer of the scalp, not only was the dura involved, but there was a prolapse of

Fig. 387.



Congenital lipoma (Bruns).

the brain the size of an apple. Recurrence is common after removal of scalp-cancers, largely because they are seldom thoroughly removed. Not only should the line of extirpation extend beyond all apparently-involved tissue, but the lymph-nodes behind the ears and in the neck beneath the

jaw should be removed, if involved: unless the tumor be easily movable over the bone, at least the external table of this should be removed, and if it be adherent to the bone, it would be much safer to take out the entire thickness of the same. Secondary manifestations are by no means rare, and in a case observed by Bergmann of epithelioma of the forehead there were nodules in the upper lid and at considerable distance.

Fatty Tumors.

These tumors in the scalp are relatively rare. Of 289 cases noted by Gurlt in his statistics, only 6 occurred in the scalp, while most of these tumors proceeded from the connective tissue beneath the skin, the others having been observed beneath the occipito-frontalis tendon and the periosteum. These tumors are most common in the occipital and frontal regions, and occur most often in the middle-aged. They have been known to appear at birth. Wheeler extirpated from a man of eighty-seven a tumor of twenty-two years' duration, which had reached a height of eighteen inches and had a circumference of fifteen inches. It sprang from the frontal and temporal region. The larger such tumors are, the more rapidly they appear to grow; they are sometimes pedunculated. Roger observed one springing from the left temple, of colossal size, which hung down nearly to the knee, which occurred in a negress of thirty-five, who had had the tumor since the second year of her life (Fig. 388).

Fig. 388.

Liponia of temporal region, displacement of palpebral fissure, etc. (Bruns).

These tumors, of course, are to be treated by extirpation.

Fibromata.

These tumors are relatively rare in and about the scalp. Gurlt found only 2 among 621 fibromata. To this variety belong, probably, certain papillomatous or papilloid tumors, which have been observed most frequently in the skull. They have an irregular upper surface, and in a

measure resemble irregular warts. Such have been described by Billroth and others. Some of these are much like the condyloma usually found about the genitals. The rarest variety is the hard subcutaneous fibroma. The most common form is a special fibroma involving the skin and subcutaneous tissue, known frequently as "fibroma molluscum." Individuals who present these lesions in any part of the body usually have them also upon the scalp; they also frequently appear on the eyelid. Tumors of this character of unusual size have been described by Stokes and Lücke.

Molluscous tumors of this sort frequently produce conditions which entitle them to the name of "elephantiasis" of the scalp. Of 7 such cases reported by Continental observers, 6 were in women, and the majority of them developed during adolescence. In 4 of these cases the occipital region was involved.

The **cause** of the same seemed to be in some measure traumatic. In a case reported by Auvert it followed a blow upon the head and repeated erysipelatous attacks. Thirion, who observed three such cases, ascribed them to the indiscreet use of the comb.[1]

To these fibromata belong also the so-called "plexiform neuromata," which, when more accurately named, are plexiform fibromata of the nerve-sheaths. These relatively rare tumors are most common in the scalp, and are most often seen upon the upper lid or just above the ear. They are observed usually in early childhood, grow slowly, and may attain considerable size. They form tumors of moderate consistence, of smooth or corrugated surface, in general appearance like the broad molluscous tumors. In some cases they are covered with a profuse growth of hair. In one such case Bruns observed a perforative defect of the underlying bone. They cause trifling, if any, disturbance. Occasionally they are very tender upon pressure. By this tenderness or accompanying pain they are to be distinguished from the flat molluscous tumors.

The **treatment** of all fibrous tumors of the skull consists of extirpation. This can be difficult only in exceptional cases, as when they are unusually vascular or are supplied by large trunks. In certain cases of elephantiasis of the scalp the tumor has to be removed in portions at different sittings. One patient of Billroth was operated on twenty times, at each sitting two or three small pieces being taken away.

Chondromata.

Chondromata of the scalp are very rare. Heineke could only find 2 cases—1 reported by Weber, the other by Israel. Chondromata of the cranial bones are more common, especially those springing from the cranial base. Such tumors may penetrate into the cranial cavity or outward. In either case they will give rise to pressure-symptoms according to their location; they may be impossible of diagnosis. Sometimes they penetrate into the nasal cavity or into the orbit. A case was put on record by Coolidge of a recurring chondroma arising just above the mastoid and seriously compromising the space for the brain within.

[1] Heineke, *l. c.*, p. 161; also Schultze, "Sehr grossen Fibroma molluscum am Kopf und Gesicht.," *Deutsche Zeitschft. f. Chirurgie*, xiii. 373.

Osteomata.

Two cases of osteomata in the soft parts, not involving the bone, have been reported by Virchow. The first occurred in a forty-eight-year-old cretin, following an injury. The second occurred in a man of sixty-seven, who had also sustained an injury, three years previously. In both cases the tumors were movable over the bone. It is, of course, possible that in each case they sprang from the outer layer of the pericranium. Gurlt, who collected 14,000 cases of tumors, found only twice osteoma of the cranial bones. Nevertheless, it hardly seems to be so rare as this, since numerous small osteomata are met with about the skull, which, causing no difficulty, never receive treatment. They may occur either externally or internally. The external forms are ordinarily regarded as exostoses; those involving the inner table are usually of spongy consistency and have been spoken of as enostoses. The exostoses are much more frequent. Sometimes they are flat and sometimes more globular, and they attain various sizes. In structure they belong to the compact type of bony tissue more often than to the spongy. In general they have a somewhat broad base, this being more frequently true of the latter. The more recent they are, the more vascular; the older, the more compact and the less vascular. Some of these tumors involve the entire thickness of the skull and project both externally and internally. The pericranium or the dura in connection with them is scarcely ever altered. Exostoses are more common about the base of the skull than the vertex, the most frequent location being the frontal bone, from which they commonly project into the frontal sinus or the nasal and orbital cavities. Exostoses of the cranial vault have also been described by

Fig. 389.

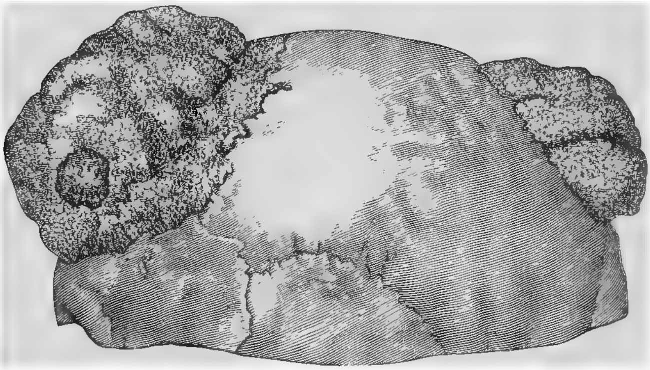
Osteoma of cranium (Bruns).

several writers. The condition seems to be essentially different from that elsewhere spoken of as hyperostosis of the bone.

Enostoses are more common in the orbit than elsewhere. They

spring from the interior of the bone—from the diploë, when this exists. For the most part, however, they have an ivory-like consistence, and

FIG. 390.



Cranial exostosis or osteoma (Bruns).

the ivory growths about the petrous portion of the temporal bone are usually, in fact, enostoses. As they grow they separate the tables of

FIG. 391.

Section of same.

the skull, and finally cause absorption, appearing themselves upon its surface.

Osteomata of the skull are more common in women than in men, and arise, for the most part, during the first years of life. As a rule, they grow very slowly, and may give rise to no serious disturbance for twenty or thirty years. Finally, they may attain considerable size, while during their development many of them give rise to more or less pain or headache. When presenting internally on the skull they usually grow so slowly as not to cause such brain-symptoms as more rapidly-growing tumors would produce. However, headache, vomiting, vertigo, loss of consciousness, muscular spasms, disturbance of sleep, or paralyses have been known to result, as well as even disturbance of speech. Toler has put on record a case of this kind—a bony tumor growing from the pos-

terior portion of the left temporal bone—which produced mostly cramps, epileptiform seizures, and, finally, loss of sleep.[1] In a case reported by Hessler meningitis seemed to have been produced by the tumor, which sprang from the posterior upper wall of the right frontal sinus and attained an elevation of 9 mm. The nerves most often involved in cases of this kind are the optic and the olfactory. Patients have been known to commit suicide because of the symptoms produced by innocent growths of this character.[2] Osteomata of the external surface of the skull are easy of recognition: those involving the cranial cavity may be suspected only by the effect they produce and by the slowness of the same. Osteomata involving the orbit produce often exophthalmos, and those of the nasal cavity may be mistaken for nasal polypi until carefully examined.

For the most part, the **causes** of osteomata are concerned with anomalies of development: being more common where bony changes occur, they grow more rapidly in early life. Syphilis has been reckoned as a cause, but has never been established as a genuine factor in the production of true osteomata.

Diagnosis.—This is to be established partly by the character of the tumor, partly by the history. As between bony and cartilaginous tumors, the age of the patient frequently helps. As between these and ossified sarcoma, the history would be of great value. In many of the internal growths exact diagnosis will be impossible; but a fact which can only be explained by a very slowly-growing tumor may sometimes be ascribed to osteoma.

Treatment.—Concerning those tumors which present externally there can seldom arise a difference of opinion, further than the necessity concerning surgical interference, providing they produce unpleasant symptoms. Osteomata distending the frontal sinus always call for operation (see Diseases of the Frontal Sinus), as do those involving the orbit and the accessory parts of the nasal region, when they give rise to symptoms. This operation may at times be easy of performance, at other times be very difficult. There is seldom any danger attending the extensive removal of an external formation, even if thereby the tumor is laid bare over a considerable area. The removal must be effected either with the chisel or equivalent instruments. The surgical engine, if made strongly enough, or some similar instrument may be of great help in these cases.

Hyperostosis.

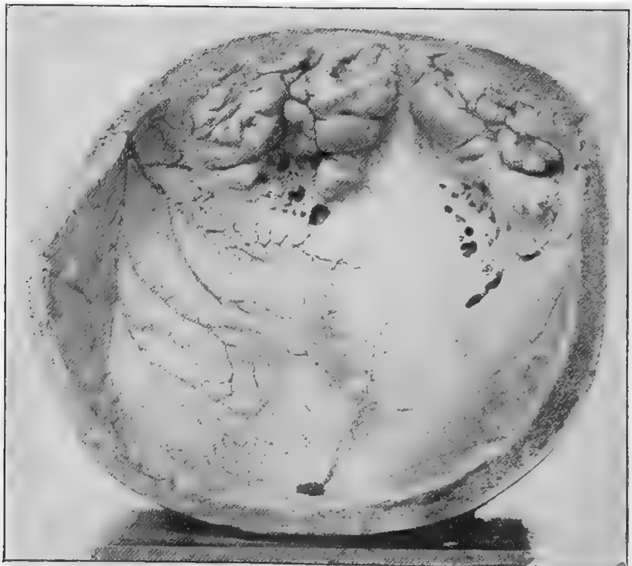
Under this name are included those cases of diffused bony formation which are not circumscribed, and consequently not entitled to the designation of tumors. Hyperostosis of the skull may be extensive or somewhat limited in the tissue involved. It consists sometimes of superabundance of osseous elements upon the external table of the skull, while at other times the entire thickness seems to be involved. The hyperostosis consists, for the most part, of very compact bony tissue; in fact, one can hardly draw the line anatomically or in a descriptive

[1] *Dublin Hosp. Gaz.*, 1857, No. 9. *Vide* also Lanphear's case, *Journ. Am. Med. Assn.*, May 4, 1895, p. 655.

[2] *Vide* Lanphear, *l. c.*

way as between hyperostosis and leontiasis, elsewhere spoken of. The bone is sometimes of soft or spongy character. A total hyperostosis of the skull has been described, involving not only the cranial, but the facial bones, even the lower jaw. These skulls are, under these circumstances, so reinforced as to have a thickness of 3 cm. or more. The general effect of this is to increase the size of the head and give the head and face a very peculiar appearance. The surface of the skull is usually more or less uneven; the vascular foramina are larger than common. The depressions for the meningeal arteries are relatively deepened, and at times converted into tunnels. The affection concerns early life as a rule, and is rare after complete growth has been obtained. As usual with these interior conditions, rhachitis and syphilis have been invoked for their explanation, but do not seem necessarily connected with it. Aside from the irregularity of contour which these skulls may present, there is little about the appearance during life to betoken the deep condition. Partial hyperostosis may give rise to certain pressure-symptoms, particularly headache and vertigo. Cases of hyperostosis, as a rule, do cause more or less disturbance, both general and of special senses, even complete paralysis of the same. A diagnosis can only be made out when the abnormal growth is external. Prognosis depends in great measure upon the age of the patient and the location of the overgrowth. So far as I know, its progress is not interfered with by treatment. A peculiar form of hyperostosis seems to have been observed in certain cases of spontaneously-healed hydrocephalus, in which case the inner table is

FIG. 392.



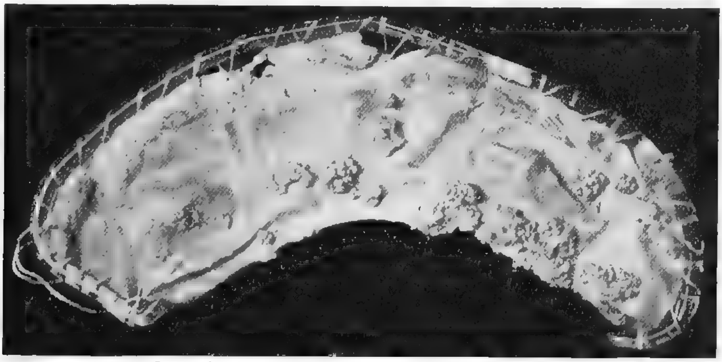
Osteophytes from inner table (Wood Museum).

most involved and the growth seems more or less to fill the space which previously existed between the bone and the soft parts beneath.

Besides these, there are the so-called osteophytes from the skull,

which are diffuse, more or less extensive bony new formations, occurring from either table, often observed, and which, when first formed, are delicate in texture and easily separable from the main bone. As they grow older they become more compact and consolidated. They are more common on the inner surface of the skull, and have been known to frequently follow injuries, peculiar contusions, chronic inflammations of the

FIG. 393.



Osteophytes of dura (U. S. A. Museum, No. 6206).

skull, and often ulcerations produced by exanthemata. They are not infrequent in hard drinkers and the tuberculous; they are perhaps most often met with in pregnant women, and it is said that in half of the autopsies upon the pregnant these growths may be found. Inside of two years, in the pathological institute of Prage, 73 times this condition was met with, 72 of the cases being women, and 47 of these patients in the pregnant or puerperal state. They very seldom produce symptoms, and most often disappear by spontaneous absorption. They are scarcely to be diagnosed, and are mainly of pathological, rather than surgical, interest.

SARCOMA.

All the tissues of the scalp may contribute to the formation of sarcomatous tumors with the exception of the epithelial. From the skin itself, from the subcutaneous tissue, from the aponeurosis, and from the muscles there may spring tumors of this general character. They grow for the most part in an outward direction and form tumors of various sizes. It is well known that soft fibromata and common warts may undergo sarcomatous degeneration and grow at a relatively rapid rate. These tumors sometimes become pedunculated and hang down from the scalp. Such a case, for instance, was reported by Dumreicher of a thirty-nine-year-old woman, whose tumor hung from the side of her head and reached down upon her shoulder. The superficial sarcoma may appear at any point; the deeper ones for the most part are found in the temporal region, where they arise from the muscles, and are, at least at first, subfascial. They are often diffuse, and a case is on record where a sarcoma spread within seven months all over the entire right side of the head and involved the ear.

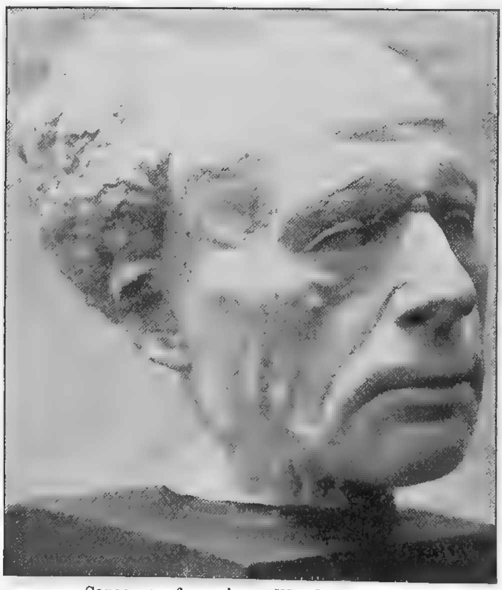
Sarcomata of the pericranium sometimes grow externally in such a way as to scarcely involve the underlying bone. Most of these tumors

belong to the spindle-celled variety, although we find mixed and melanotic growths here as well as elsewhere. They undergo various degenertions—cystic, myxomatous, etc. The region of the orbit is a favorite site for angio-sarcomata, which sometimes include that form of hyaline degeneration which has caused it to be given the name of "cylindroma." Sarcomata appear at any age, yet are relatively rare during the first ten years of life. In the majority of instances there is a history of injury. Duhring has reported a case where the excitant cause seemed to be an eczema. These tumors run a course similar to that which we see in other parts of the body. They are often multiple, and récidives seem to be common. Local metastasis is frequent, but general metastasis is rare. Difficulty in diagnosis can very rarely arise, although by Vidal and by Bruns sarcomata lying deep in the temporal region and perforating the deeper temporal and orbital regions have been known to give rise to pulsating tumors which have been mistaken for aneurysms.

SARCOMATA OF THE BRAIN AND MEMBRANES.

These may proceed from the base or from the vertex. The former frequently penetrate into the nasal and orbital cavities, where they may give rise to peculiar symptoms. For the most part, they spring also

FIG. 394.



Sarcoma of cranium (Wood Museum).

from the periosteum, sometimes from the spongy structure of the diploë. The periosteal sarcomata, for the most part, grow away from the bone but sink into it as might any other growth. These tumors are more or less altered by ossification or calcification, which latter degeneration takes place at that part nearest the bone, so that while such a tumor may be

soft at its apex, its base may be as hard as the bone from which it springs. The medullary sarcomata arise from the diploë, and growths of this character usually widely separate the tables of the skull before perforating them. In this sort of bony capsule such a tumor may grow until it has attained considerable size, when resorption of the internal and external tables goes on. After a while it bursts through the compact table and then spreads out upon its surface. In the latter case it may then so attack the periosteum as to be from this time on indistinguishable from the ordinary periosteal growths. The medullary growths for the most part are composed of giant-cells, are located barely outside of the bone, and leave a defect which may be surrounded with osteophytes or may be felt as a bony margin around the soft growth. The growths which proceed in this way involve and usually penetrate the dura. In individual cases the dura may be penetrated at one or several points, at which proliferation proceeds in resemblance of a fungous outgrowth. The external growths frequently assume large size, especially when they are spread out over the bone, as sometimes happens. They are frequently multiple. Similar tumors may be observed in other parts of the body. In one case, observed in Erlangen, in a man of forty-one, there was a period of ten months between the development of the first tumor in the occipital region and the second in the temporal region; at his death numerous tumors were found in the dura and in the lungs. Arnold has reported a case of similar tumor in a man of forty-nine, in whom, after death, sarcomata were found in the clavicle, the liver, and the spleen. The neighboring lymph-nodes are very seldom involved.

The majority of these sarcomata are spindle-celled, among which cystic changes are quite common. Next to the spindle-celled variety comes the round-celled in order of frequency. It is important that in most of these cases there is a previous history of some injury. It must not be forgotten, however, that these tumors of the scalp and cranium may be secondary to those elsewhere about the body.

Gussenbauer[1] has reported a case of primary myelogenic tumor of the frontal region in a patient twenty-five years old, with results of operation. Having first taken out the entire external table from the right side of the frontal bone and beyond, he thus exposed the tumor, which lay in the diploë, from which it was removed with blunt instruments. After its removal an extensive surface of dura was exposed. He replaced the soft parts with perfect success.[2]

SARCOMA OF THE DURA.

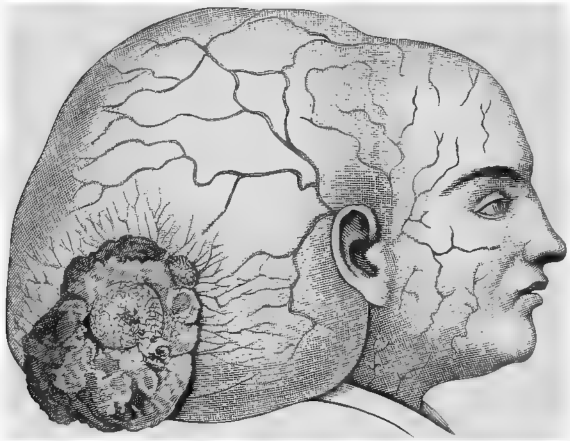
Sarcomata springing from the dura develop for the most part in the direction of the cranial cavity and bury themselves in the brain, causing disturbance which eventually kills the patient. A small portion of these growths which spring from the external layer of the dura may develop between it and the bone. In the latter case the bone becomes thinner

[1] "Beitrag zur Kenntniss und Extirpation der Myelogenen Schädelgeschwulste," *Prag. Zeit. f. Heilkunde*, vol. v., 1884.

[2] See also Kocher, *Virchow's Arch.*, vol. xliv. p. 311; Schreiber, *ibid.*, vol. liv. p. 285; Arnold, *ibid.*, vol. lvii. p. 297; Rustizky, *Deutsch. Zeit. f. Chir.*, 1873, p. 162; Küster, *Berlin. klin. Woch.*, 1881, No. 46; Heineke, *l. c.*, p. 177 et seq.; Lebert, *Virchow's Arch.*, vol. iii. p. 463.

and thinner until it is no thicker than paper, and then gives way; after which the defect is increased in size and the growth appears upon the outer surface. The relations of these tumors are not always the same. They are frequently surrounded by a sort of capsule, which may be formed from the external layer of the dura. When the tumor is not

FIG. 395.



Ulcerating sarcomatous tumor of dura (Bruns).

firmly imbedded in the bone, it is sometimes movable inside of the very defect which its growth has caused, so that it can be pressed into the cranial cavity, provided, of course, that its external surface is not too voluminous. The edges of the opening thus made are thin, smooth, and round, but when the tumor is of a rapidly-growing variety or has existed for some time, this peculiar feature may be lost. Sarcomata springing from the dura at the base sometimes penetrate outward through the orbital fissure or other foramina. Some remarkable instances have been reported of tumors whose primary location was really the external layer of the dura, and which had grown outward until they had assumed relatively enormous size. So soon as a tumor has thus perforated and appeared upon the surface it is not to be distinguished from one of purely external origin, except possibly by the history of the case. In size these tumors vary very much.

Volkmann observed a sarcoma, springing from the dura, which attained such size as to spread over the side of the head down to the clavicular region, and finally hung down even to the forearm. Dural sarcomata seem less likely to be complicated by metastasis than those springing from the bone itself. The lymph-nodes are seldom affected. The most common site for dural sarcomata is in the temporal region. For the most part, these tumors are met with after middle life; they are not unknown, however, in children, and Bruns has recorded two cases in children where they seemed to have been of congenital origin.

So far as the **symptoms** are concerned, they usually give rise to pain, which is frequently the one constant feature. Vertigo, vomiting, and other symptoms are uncertain and variable; paralyses of special nerves

or of special areas may, of course, be caused by pressure in specific directions. It is astonishing how little disturbance may be produced by tumors of great size. In a few instances hyperæsthesia has been noted. Auvert observed one instance where upon pressing the tumor backward into the skull fainting was invariably produced;[1] at one time this patient received a blow upon the face which forced the tumor back, and she remained unconscious until it had escaped into its normal position. In another case, reported by Klein, the patient lost the power of speech so soon as the tumor was pressed into the cranial cavity. In practically every instance, however, when death has been the result of these growths there have been peculiar symptoms, for the most part those of pressure on special nerves. Some of these patients have probably died from the mere effects of pressure; others, from exhaustion; some from sepsis, and some from hemorrhage. Sometimes these tumors attain a size which gives rise to œdema of the neighboring parts, so that the face may be swollen almost beyond recognition. Purulent meningitis and encephalitis are by no means uncommon.

The **duration** of these growths is very uncertain. Some cases end fatally in six months, while others live five or six years. In one case, reported by Dumas, the growth lasted over twenty years.

Diagnosis is seldom difficult, and consists merely in differentiating this form of tumor from others, for the most part from innocent growths. This distinction must be made partly by the history and partly by the location and clinical course of the tumor. Many sarcomata of the skull, and even of the dura, are somewhat reduced in size by continuous pressure, which seems to empty their vascular channels, but their original size is quickly restored when pressure is relaxed. On account of their exceedingly vascular character a mistake may arise in regarding these growths as angio-sarcomata, or one may have to distinguish between one or the other of these and an aneurysm. Thus it has happened to Bardeleben to regard one such case as an aneurysm, discovering his mistake only after ligature of the common carotid. There is possibility of confusion between these growths and meningoceles with firm coverings, or encephaloceles. A study of the case-history will be of great importance in avoiding this error. As between sarcomata of the bone and of the underlying dura, one may feel sure that a tumor which protrudes through an opening whose borders are reasonably smooth must arise from a deeper location, especially when there is pulsation in the brain beneath. The possibility of reposition of such tumor within the skull would confirm this view. Tumors arising from the bone, even though they cause resorption of the same, are usually too firmly placed to permit either reposition or recognition of the bony opening. In the absence also of signs of brain-pressure we may find argument for or against one or the other growth.

Prognosis in these cases is always bad; the tendency is steadily toward death, and it has been but lately that the surgeon has been able to make such complete extirpation that recurrence has been avoided.

Treatment naturally consists of extirpation when it can be effected. When the bone is at all involved, it should be completely removed from a considerable area around the growth; when the dura is involved, both

[1] *Clinica et Iconographia Méd.-Chir.*, Paris, 1848.

dura and bone require removal. More than once this has necessitated ligature, particularly of the superior longitudinal sinus; but we know that this can be practised with very little fear of resulting disturbance, even though it should be necessary to take out a section of the sinus. In any case where the tumor is in the slightest degree adherent to the sinus both should be removed. Considerable ingenuity may be required to cover the defects resulting from some of these extensive operations and to afford a suitable skin-covering for the exposed dura or brain.

Circumstances may arise where it would be wise to remove an ulcerating tumor or one causing mechanical disturbance, even though there could be nothing but prospect of recurrence, the operation being done for temporary relief. Operators at the present day much more freely open the cranial cavity than did those of any previous era. Most of the danger comes from possible purulent infection; aside from this, the main danger is from hemorrhage, since many of these tumors are extremely vascular. The large vessels occur mostly in the soft parts, and since, by the use of an elastic tourniquet, we may in large measure control this hemorrhage, we may now operate with less fear of serious consequences. When the large sinuses are enlarged they increase the danger from air-embolism. Volkmann lost a patient, from whom he removed a dural sarcoma, by this accident. With these facts before us, as well as with the assurance which we now feel concerning the safety of preliminary ligation of all the large venous channels about the head, we may so manage operations as not to incur this risk.

In another place I have alluded to the danger of using the hammer and chisel too frequently about the skull, because of the extreme shock which seems to be in this way produced. The experiences of Koch and Filehne,[1] as well as those of many other operators, indicate that a dangerous degree of shock is often produced by the repeated concussions of the hammer used for this purpose.

In the older literature only two cases were recorded in which these operations terminated successfully, and until quite recently they were not regarded with favor by general surgeons. Quite lately, however, such operations have been successfully performed by a number of operators. In one case, for instance, reported by Küster, a large portion of the frontal bone with the corresponding piece of the dura was excised, in spite of which the patient made a complete recovery.[2]

Carcinomata of the Skull.

Inasmuch as the true carcinomata are essentially epithelial products, among which we, for convenience, here reckon the epitheliomata, it is not to be expected that these tumors will be often met with in any other place than upon the integument. By all means the most common of these are the epitheliomata, which are not at all infrequent about the scalp. Many of these lesions are the result of malignant degeneration of previously more or less benign tumors, such degeneration occurring frequently in the aged or in those exposed to frequent irritation. There is so little to be said here which does not apply equally to similar tumors

[1] *Arch. f. klin. Chir.*, vol. xvii. 190.
[2] *Berlin. klin. Wochenschft.*, 1881, Nos. 45, 46.

elsewhere in the body that we dismiss the subject with very few words, advising only the radical removal of all tumors which are at all suitable for operative attack, and that not merely the soft parts, but usually the underlying bone, should also be extensively removed, and that a wide region of apparently healthy tissue should be excised at the same time, in order, so far as possible, to ensure against recurrence. There is as little to be said in favor of the application of caustics and pastes for the treatment of these conditions on the head as anywhere else. They are only to be resorted to when the positive instructions of the patient or other good and sufficient reasons make it injudicious to operate under an anæsthetic.

Echinococcus Cysts.

These belong to the rarest diseases of the skull. They may be found in the scalp, in the bones, or in the cranial cavity. Of echinococcus cysts of the scalp I have only been able to find one instance, reported by Guttmann—that of a man of twenty-six, who for six years had a fluctuating tumor in the temporal region, which gradually increased in size and gave more and more trouble, and was finally evacuated by incision, its contents being typical of its condition. Echinococcus cysts of the orbit have been somewhat frequently observed. Of the bones of the scalp there are at least three cases on record—namely, by Dupuytren, Keate, and Langenbeck. In these cases the tables of the skull had separated, and more or less resorption of bone was produced by the pressure of the cyst. In the interior of the skull these cysts are more common. They have occurred between the dura and the bone, beneath the dura, or in the brain-substance itself. Extradural cysts may produce absorption of the overlying bone, as do the more solid tumors. This was the case in an instance reported by Peinemann and Moulinié. The subdural cysts and those in the brain occurring in young patients produce both thinning and distention of the bone, as well as other signs. In a case observed by Rodust the skull was generally enlarged and the sutures were loosened. As a rule, the alteration is local rather than symmetrical, and leads to the projection of the bone over the seat of the tumor. In a case reported by Réer, of a five-year-old child with echinococcus cyst in the brain, the dura mater had been perforated and the overlying bone widely absorbed. Most of the echinococcus cysts in the brain, however, do not attain such size as to produce external alterations. For the most part they consist of single cysts containing daughter-cysts, and are usually single rather than multiple.

An echinococcus cyst of the scalp appears slightly rounded in shape, fluctuating, more or less transparent, sometimes yielding characteristic sensation under the finger. By pressure upon the nerves or by inflammatory process it may give rise to more or less pain. Cysts of this variety within the orbit push forward the globe of the eye and cause more or less loss of vision. Echinococcus cysts of the cranial bones form tumors which are for a long time hard, but which later become soft and fluctuating as the overlying bone disappears. When they work their way through the skull from within pressure upon them may produce brain-symptoms. Cysts arising entirely within the skull grow

slowly, and produce brain-symptoms in proportion to their size and in accordance with their location. Their tendency is always to kill unless relieved by surgical means.

Echinococcus cysts can only be surely diagnosticated after puncture or spontaneous evacuation, and then only by examination of their contents. Colloid cysts and daughter-cysts are the characteristic features of these contents, while the fluid itself is slightly albuminous and contains succinic acid. Cystic tumors which are suspected to be of this origin should be carefully investigated in the light of the above statement. So long as they are covered by unbroken bone their character cannot be made out with any certainty. Should, however, the tumor cease to develop, or, particularly, should it decline in size, its hydatid origin may be suspected. In case of doubt the exploring needle should be used, and enough of the fluid aspirated to permit both chemical and microscopical examination. Cystic tumors of this kind which protrude from otherwise unaffected bone undoubtedly have their origin between the dura and the bone. Important corroborative evidence would be the discovery of other hydatid cysts in other parts of the body.[1]

Diseases of the Blood-vessels.

SIMPLE ANEURYSMS.

Aneurysms of the cranial arteries are, as a rule, rare, because of their relatively small size. Of them all, the temporal is the most frequently involved. Such aneurysms are, for the most part, of traumatic origin, occurring rather as the result of division or of subcutaneous crushing. Falls upon the head or blows with blunt objects may produce them, while their most frequent cause in times past was the phlebotomy or section of the temporal vessels at one time commonly practised. When these aneurysms are traumatic, they may occur a few days after the injury or not until several weeks. They present all the characteristics and signs of true tumors, but produce no reflex disturbances, although patients may complain of a peculiar sound which they hear as a purely subjective sensation. These aneurysms may enlarge until they attach themselves to the skin, and even spontaneously rupture, as Poinsot has observed in one case of aneurysm of the occipital artery.

Diagnosis is usually made without difficulty; but in those cases in which the aneurysmal dilatation involves a branch as well as a main trunk the question of differential diagnosis may arise.

So far as their **treatment** is concerned, there is no part of the body in which they can be more easily or radically attacked. Should simple compression be insufficient, it would probably be best to make thorough extirpation, tying on either side of the sac and treating it as one would attack any other tumor.

CIRSOID ANEURYSM.

Under this term is understood that form of enlargement of an artery which includes both its diameter and its length. It is met with ordi-

[1] *Vide* Heineke, *Chirurg. Krankh. des Kopfes*, p. 200 et seq.

narily as a more or less bosselated enlargement of a vessel, sometimes to a relatively enormous size; there is an absolute increase in length as well as of diameter, and as the artery elongates it becomes tortuous and serpentine, sometimes spiral. It involves commonly several trunks with their branches. It may occur in the arteries of an extremity, but is particularly often seen about the scalp. Sometimes it extends from one side over to the vessels of the other side. The capillaries may be widely dilated, and even the connecting veins involved. When it has existed for a long time and has effected such changes as these, it is frequently known as *aneurysm by anastomosis*, or *racemose aneurysm*. The superficial temporal, the posterior auricular, and the occipital vessels are those most frequently involved.

The **causes** of this condition are very obscure. It has been at times referred to injury, especially of a congenital erectile tumor, but most

Fig. 396.

Cirsoid aneurysm (Bruns).

often no cause can be ascribed. The majority of cases occur between twenty and thirty years of age.

The **diagnosis** can scarcely be difficult, since the serpentine and pulsating character makes its nature plain.

The **treatment** of these aneurysms is often difficult and dangerous. Operative attack frequently fails, and there is still greater liability to relapse, while fatal terminations have been in the past not infrequent. The simplest method is by compression; it is also the most ineffective. Ligature of the external carotid on one side or both, or, as is necessary sometimes, of the common carotid, is the measure which in these antiseptic days has given the most perfect relief. Sometimes, in addition to this or as a later operation, more or less exsection of the vessels or the vascular tumors can be made. It would hardly be well to do all this at once. While ligature of the common trunk has in time past been

serious, and too often fatal, it is likely that most of the fatalities occurred from lack of aseptic precautions, and that with these the danger will be reduced to a minimum. Primary excision of the tumor has been several times accomplished, and has been satisfactory in some cases of great severity. These tumors have also been treated by galvano-puncture, by coagulating injections, and by other means. All of these, especially the injections, offer possibility of danger which may easily pass beyond control, and they are to be avoided if possible.[1]

ANEURYSMS OF THE ORBIT.

Heineke could find but two cases of spontaneous aneurysms of the orbital vessels—one reported by Guthrie, the other by Carron du Villards. The former was found in the cadaver; the latter was observed clinically. He also met with but two recorded cases of traumatic aneurysms of the ophthalmic artery, reported respectively by Passavant and Lawson. Orbital aneurysm, therefore, is a sort of curiosity. Aneurysms of the external vessels have also been noted, and Hotz, for instance, has reported a traumatic aneurysm in the upper eyelid. The symptoms of orbital aneurysm consist for the most part of protrusion of the bulb and in the existence of an arterial impulse synchronous with systole. It can be checked by pressure upon the common carotid. A bruit is also sometimes to be heard. I believe it may be held that coincidence of pulsating exophthalmos and bruit are pathognomonic. Aneurysm of the ophthalmic artery inside the skull has been observed in one instance by Nunneley. The above symptoms might be imitated in the case of traumatic or spontaneous rupture of the internal carotid into the cavernous sinus, by which we would have aneurysmal varix of the sinus and the ophthalmic veins, which would produce very serious symptoms. In this latter case, however, there would be also dilatation of all the orbital veins as well as those of the supraorbital region, in which probably pulsation could be both seen and felt. In spontaneous cases these appearances would occur gradually; in traumatic cases they would be of immediate origin.

Prognosis of orbital aneurysms is never favorable, since partial or complete amaurosis would probably result from pressure around the optic nerve.

Their **treatment** can only be direct in case it be easy to recognize a pulsating tumor in the orbit; in which case, possibly, a ligation of the artery involved could be made. Electro-puncture might be resorted to: the injections of liquor ferri, recommended by Heineke, seem to me too dangerous. Should compression of the internal or the common carotid abate the pulsation, it would be surgical to tie this vessel at the point of election.[2]

ANEURYSMS OF THE MENINGEAL ARTERIES.

Of these only the middle has been found to be involved, and of such tumors there were up to 1882 but ten cases on record. Most of these

[1] *Vide* Terrier, *Des Anévrysmes cirsoïdes*, Paris, 1872; Hildebrand, "Behandlung des Angioma arteriale racemosum, besonders des Kopfes," *Deutsche Zeitschft. f. Chirurgie*, xxxvii. 236.

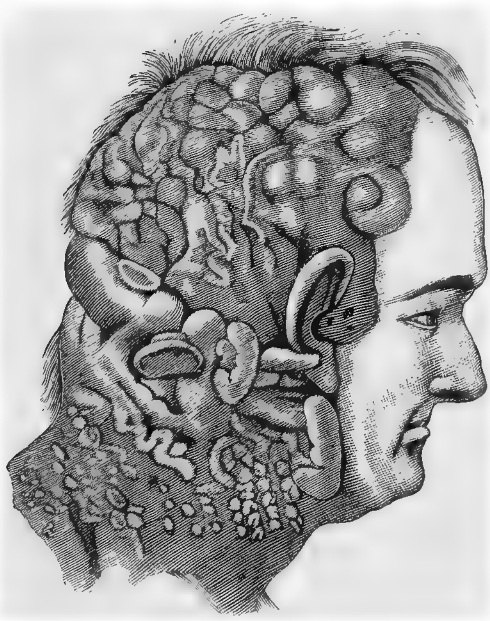
[2] *Vide* also Terrier, "Tumeurs vasculaires du cuir chevelu," *Revue de Chirurgie*, 1890, x. 47.

appear to have given rise to absorption of bone by pressure, so that an easily recognizable tumor appeared beneath the scalp. In at least one case this was mistaken for a cyst, was freely opened, and the patient died of hemorrhage. It is not difficult to account for this condition, and it is surprising that these instances are not more frequent. In the canal or groove in which the artery runs the vessels cannot always escape injury when fracture across their course is inflicted. Unless rudely lacerated, they frequently give rise to compressive clots, as is well known. It may thus happen that a trifling tear in the arterial wall may lead to the formation of an aneurysm, especially when the course of the vessel is through a complete canal in the bone.

Diagnosis of this form can only be made when the tumor presents externally by absorption of overlying bone. In such a case, by examination of the tumor itself and comparison of the effects of pressure upon it and upon the large vessels of the neck, a conclusion can probably be arrived at.

Treatment of these cases must, for the most part, be by ligature. In one case Consolini could obliterate by digital compression. When ligature is applied it may be either to the common or to the internal carotid,

FIG. 397.



Varicose aneurysm (Bruns).

or, better still, when feasible, to the middle meningeal itself. This should be exposed in its course as freely as necessary, and ligated, if possible, on the proximal side.[1]

[1] *Vide* Heineke, *Chirurg. Krankh. des Kopfes*, p. 44 et seq.; Kremnitz, "Aneurysma arteriæ mening. med.," *Deutsche Zeitschft. f. Chirurgie*, iv. 473.

ARTERIO-VENOUS ANEURYSMS.

These are even rarer than true aneurysms. Bruns collected 4 cases, to which Heineke has been able to add 5. Of these, 1 concerned the posterior auricular artery and vein, 7 the temporal artery and vein, and 1 was composed of vessels which have no names. In them all the tumors seemed to have that form known as "aneurysmal varix," the arterial blood emptying directly into the injured vein. The progress of these tumors is not rapid, and after a while they seem to come to a stop. A patient of Czerny lived for twenty-five years, his tumor making very slow progress during this time. Aside from the murmur produced from the current of blood he had but little to complain of. The ease with which these tumors can be injured, and the fact that fatal hemorrhage may result from them, are taught by a case of Biefel's.

The **diagnosis** of aneurysmal varix of the skull is of little difficulty, because of the extent over which the tumor is spread out, and the fact that its vascular character makes it easily distinguishable beneath the skin.

The most important element in the **treatment** of these tumors is the shutting off of arterial blood-supply, which is not always easy. In Biefel's case the collection, for instance, was above the principal lesion, and proceeded not from a large vessel, but from a small one. Accordingly, he extirpated the principal part of the varix with the dilated veins adjacent thereto. In similar cases we should have to imitate his procedure. On the other hand, if the artery is easy of access, it should be exposed and ligated, which is usually enough to produce obliteration. In Czerny's case he extirpated nearly all of the growth.

ARTERIO-VENOUS ANEURYSMS CONNECTED WITH THE ORBIT OR A SINUS.

Heineke could find but one case of this kind in literature.—that reported by Lansdowne[1] which had to do with an injury of the upper lid. In this case after six weeks there appeared prominence and swelling, first of the lid and later of the conjunctival veins. Four weeks later there formed a pulsating tumor in which there was a continual bruit, which ceased on pressure upon the carotid. The sac was complete. The tumor was incised, ligatures applied upon either side, and healing resulted.

Of great diagnostic importance are the orbital veins, which may indicate a communication between the internal carotid and the cavernous sinus. Such a communication might possibly be brought about by penetration of a bone-splinter in a fracture of the base. In any such case the arterial blood which passes into the cavernous sinus would prevent the return of venous blood and cause passive venous engorgement of all these veins which empty into this sinus or into the orbit, causing also choked disk, œdematous inflammation of the orbital cellular tissue, chemosis, pulsating exophthalmos, dilatation of the pupil, and expansion of the supra- and infraorbital veins. The subjective and objective signs above given would be in a general way the symptoms of this condition.

[1] *Brit. Med. Journ.*, June 5, 1875.

Rizzoli observed one unique case in which there was communication between the occipital artery and the transverse sinus.[1] This was probably the result of some congenital anomaly.

Venous Tumors of the Cranium.

PHLEBECTASIC VARICES.

Dilatations of the superficial veins in the skull are often observed. They are most commonly noticed when they pertain to the frontal and temporal regions. They form mostly during the earlier years of life, and seem to be due in a large measure to a weakness of the venous walls, which yield when pressure is increased, as it may be by violent coughing or chronic congestion by alcoholism, etc. Varices of more distinct form appear in one of two shapes—either the varix simplex, which is a saccular dilatation of distinct veins, or a general dilatation of a group of veins with their ramifications—*i. e.* varix racemosus. These venous dilatations are not painful, and cause the patient very little difficulty. Generally they cause depressions in the underlying bone, and are more or less buried in the same. Obviously, they will bleed seriously when injured, and are mainly of serious account for this reason. They are best left alone or else treated radically by extirpation of the entire varix.

VARIX SIMPLEX COMMUNICANS.

By Bruns[2] similar conditions of the upper lid from varices of the orbital veins have been reported. Communicating venous tumors of another kind are illustrated by the following case: A soldier had received a blow upon the forehead. The injury seemed to have caused fracture with depression. After twenty-four hours' unconsciousness he slowly recovered. At the site of injury there gradually formed a tumor which finally attained the size of a hen's egg and was bluish colored. It increased in size when he lay down, diminished when he held the head erect; respiration had no influence upon it. The overlying skin was abnormally thin; there was evident depression of bone. The tumor fluctuated, and could be caused to almost disappear on pressure, which, however, caused him pain and vertigo. The tumor did not pulsate nor were any murmurs heard in it. He died of erysipelas. Upon autopsy there was found just outside the bone a blood-sac covered with periosteum and skin. In the underlying depressed bone were numerous small openings which permitted the passage of veins into the superior longitudinal sinus. The inner side of the bone was normal.[3] Numerous similar cases have been reported.

Most of these cases have shown alteration in the size of the tumor, depending on the position of the head. In two cases it was shown that pressure around the periphery of the tumor did not prevent its filling; in another, that compression on the jugular vein produced the greatest distention of the sac. In such cases as these there can be no doubt that one has to do with a sacculated collection of venous blood as a result of

[1] *Mem. dell' Acad. delle Sc. dell' Ist. di Bologna*, 1873; *Schmidt's Jahrbuch*, Bd. 168, p. 216.
[2] See paper of Mastin (foot-note, p. 531).
[3] Heineke, *l. c.*, p. 59.

injury by which the periosteum is separated from the bone, and which is fed with veins that connect directly or indirectly with the sinus. There is a possibility of such result after fracture with laceration of the sinus or after separation of the periosteum at this point, where well-known emissaries pass through the bone. The depression of bone which is usually a concomitant feature may be due to injury or to absorption. This condition has been called by Dufour "fistule osteo-vasculare;" by Stromeyer, "sinus pericranii;" by Hecker, "varix spurius venæ diploetici."

Finally, there is a class of blood-tumors concerning whose nature one cannot be quite certain. These are the so-called hernial dilatations of the superior longitudinal sinus. Cases of this kind have been reported by Beikert, Flint, Busch, Ogle, Chassaignac, and others. Beikert's case was known only as an anatomical specimen. In the other cases the tumor was either congenital or developed early in childhood. These tumors usually present through openings in the bone. Pressure upon them causes vertigo and, perhaps, crying, while by compression on the jugular veins they are made more prominent and blue. In a case of Demme's the tumor dilated with each inspiration. In a case of Glattauer's it pulsated and murmurs were heard within it. In this latter case choked disk and sudden blindness seemed to indicate a sudden exaggeration of intracranial pressure. Of 7 cases the tumor was 6 times in the occipital region; in 1 of these the tumor reached the size of a robin's egg. In Demme's case the sac of the tumor was found to be of the same structure as the sinus-wall. In the case of Foucteau there were found two accessory sacs containing serous fluid. The opening into the sinus was as large as the little finger. By Heineke[1] these tumors are regarded as a peculiar form of encephalocele, which, he reminds us, is often connected with hydrocephalus; and its complications are found in the cases reported by Glattauer and Ogle.

So far as the **diagnosis** of these venous tumors goes, we find, for the most part, that they are easily compressible, that their size depends in a measure upon the position of the head, and that some of them are influenced by respiration; that compression of their periphery does not hinder their filling; that when compressed such pressure ordinarily increases intracranial pressure; and that there is corresponding increase of pulsation. They may be distinguished from simple varix by the fact that pressure upon the periphery seems not to influence them, which also distinguishes them from racemose varix. Various spurious formations and circumscribed tumors lie usually in bony depressions, but are less influenced by pressure.

There are other conditions quite likely to lead to confusion. We have to distinguish between the aneurysms, aneurysmal varices, and encephalocele. Most of the aneurysms are fed from the superficial arteries. Pressure upon them can be made significant; so, too, with aneurysmal varices. There can almost always be found a communicating artery, pressure upon which will stop the pulsation in the tumor. As between these venous tumors and encephaloceles diagnosis may possibly be difficult. It will be easier, however, by noticing the bluish tint of the venous tumor, which cannot be mistaken for the more bluish

[1] *L. c.*, p. 63.

skin over an encephalocele when its veins are filled. The reducibility of the tumor upon pressure may be quite similar, as well as its consistence; but an encephalocele will not fill fuller and expand by compression of the jugular vein, as will be the case with a venous tumor.

Treatment of these venous tumors, so far as the deeper forms are concerned, is not very satisfactory. In 3 cases tumors have been incised. In Flint's case it made a very serious hemorrhage. In a case reported by Pelletan the hemorrhage was so serious as to call for styptics. As a result of their use there may set in a purulent meningitis, which may carry off the child. Azam made an incision through the traumatic varix, which was followed by no serious trouble, and later healed Merssemann healed one such case by continuous compression. Bardeleben succeeded in healing one communicating tumor by electro·puncture; but in most of the cases no attempt has been made, because of anticipated danger.[1]

NON-INFLAMMATORY CONDITIONS OF THE SKULL.

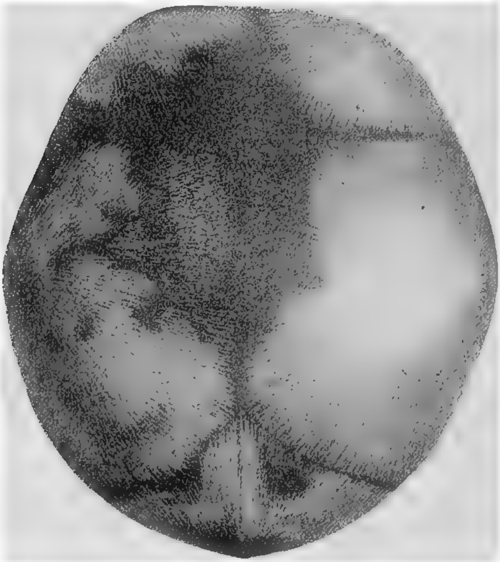
INCOMPLETE FORMATION OF BONE; APLASIA CRANII; OSTEOGENESIS CRANII IMPERFECTA.

The skulls of the new-born are sometimes found to be incomplete, the bone being more or less deficient. At other times the bones of the vertex are found unduly thin and flexible, and almost transparent in spots, with lines running along them, marking them like the ribs of a leaf. In certain instances also there will be found complete defects, so that the bone appears to have been perforated. For instance, Boecker found in the skull of a child thirty-three days old that but a small portion of the occipital bone and of the petrosal was composed of really osseous tissue. These defects, however, are more commonly met with in the region of the frontal and temporal bones. These are sometimes as thin as paper, or the osteo-cartilaginous tissues will be found extending outward in radial stripes, or isolated patches of bony tissue will be found which serve to separate the periosteum and the dura in small patches. In cases of moderate aplasia there are often other disturbances of development, particularly in the osseous system, which appear during the early months of childhood. The ossification may come on gradually with some delay, or it may proceed from various centres, which are in this sense abnormal, since they do not accord with the general plan of ossification. The fragments of bone thus produced freely blend together, and may eventually make a skull practically as good as a normal one. Under these circumstances individual bones may be developed which are more than mere Wormian bones and yet receive no definite names. Ogle and Paget have described interesting cases of this kind. Probably the

[1] A very interesting monograph by W. M. Mastin on "Venous Blood-tumors of the Cranium" was published in 1885 in the *Annals of Surgery*, and continued in the *Journ. of the Am. Med. Asso'n*, 1886, September and October. He calls attention to the fact that these tumors have been known by various names aside from those above given; as, "osteovascular fistulæ," "erectile tumors of the skull," "sanguineous tumors of the vault," "sanguineous herniæ," "varicoceles of the skull," "subpericranial venous tumors," "reducible sanguineous tumors of the vault," etc.; and he classifies them as, *a*, congenital; *b*, spontaneous; and *c*, traumatic. For further information with regard to these surgical curiosities the reader must be referred to his paper.

most perfect specimen of its kind, however, has been described by Vrolik:[1] The skull consisted of a great number of cranial bones, for the

FIG. 398.



Aplasia cranii: incomplete ossification (Bruns).

most part united, leaving a few osseous defects. A similar case, found in the Würzburg Collection, has been described by Bidder. Some of

FIG. 399.

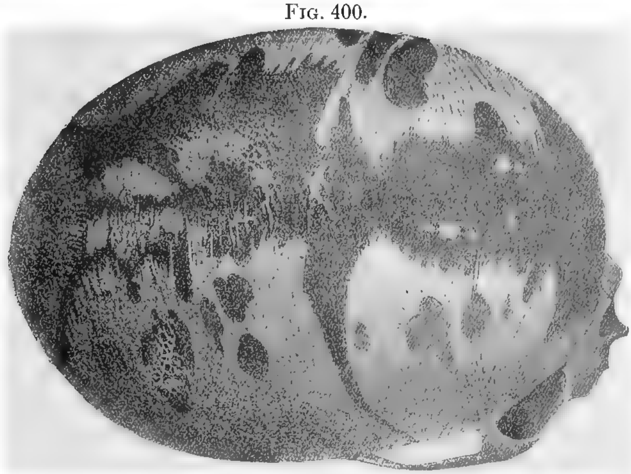
Aplasia cranii: incomplete ossification (Bruns).

the children born with these peculiar skulls are in other respects well formed; others are defective. In some of them there has been such

[1] *Tabulæ ad illust. embryogen, etc.*, Amstelodam, 1849.

complete failure of true bone-development as to cause them to be regarded as cases of fœtal rhachitis. When the history has been secured

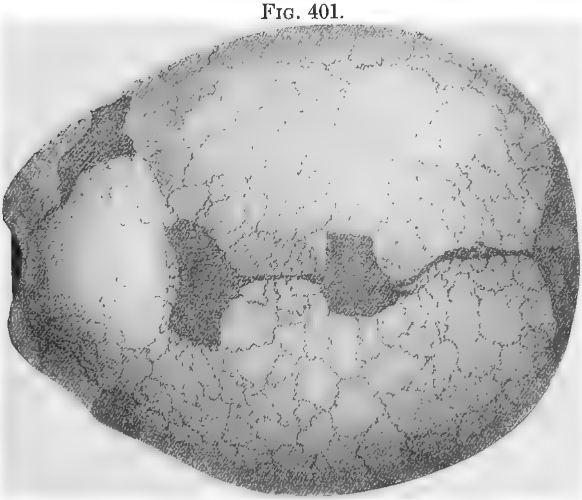
Fig. 400.



Same as Fig. 399: view from above.

it has almost always been found that the parents were badly nourished, particularly the mother, while in some of them a history of syphilis plays an important part, as it certainly did in Vrolik's case. These conditions are more essential than are those obtaining in ordinary hydrocephalus, since in the latter case it is the increasing pressure which prevents the proper ossification of the bones.

Fig. 401.



Incomplete ossification of different type (Bruns).

Aplasia seems to be at times a unilateral defect, and under these circumstances may contribute toward the formation of meningocele. He-

reditary influences may be concerned in these cases; and Frank has recorded the case of a woman who bore three children successively, all of whom showed lateral defects in the frontal region. In this case, however, he found in the mother a tumor involving the promontory of the sacrum, and this it was which probably interfered with ossification of the fœtal skulls. Again, the presence of cystic and dermoid tumors has been known to prevent ossification. It is quite probable that many cases of apparent defect of ossification in adults are due to the presence at some time of such tumors rather than to a primary or original aplasia.

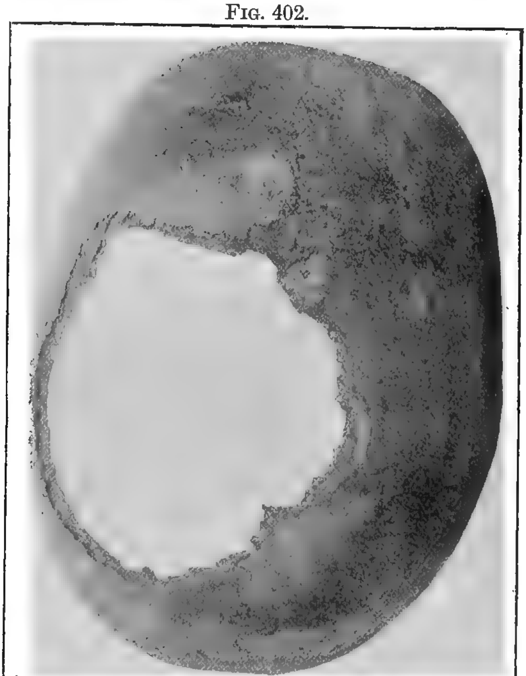
In many of these instances it may be possible to protect the growing skull by means of some material moulded on a cast, which shall be protective both from within and from without. Celluloid or gutta-percha would probably answer this purpose.

Disappearance of the Cranial Bones.

ATROPHIA SEU ANOSTOSIS CRANII.

In the skull complete disappearance of bone-substance is not infrequently observed. It may come on as an interstitial or as an excen-

Fig. 402.



Absorption of bone (Wood Museum).

tric anostosis. Interstitial atrophy may happen at any point, and resembles atrophy of any other part of the bony skeleton. Excentric atrophy begins at one or more points and proceeds in a centrifugal direction, the

bone disappearing along the margin of the opening already resulting from the process. This is quite common in the skulls of the aged, and by it large bones have been reduced to the thinness of paper. Complete perforation may even result in this way, and the opening thus made may have considerable extent. It is practically nothing else in these cases than the senile atrophy which is met with in the other parts of the body. When it begins with the diploë, the bone becomes more spongy and porous and the marrow more vascular and dark. This condition is usually diffuse, but sometimes circumscribed. In hyperæmia of the diploë it often presents an almost inflammatory appearance, the cause being unknown. This is accompanied by no signs, and may not be suspected during life. It seems to be almost of the same character as osteomalacia.

Of more practical importance is excentric atrophy beginning on the outside. The shape and size of the opening thus produced may vary very much. It may be produced by pressure of a tumor and in many other ways. The most common causes of pressure are the so-called "Pacchionian granulations." The depressions in which these lie are everywhere recognized; around them we meet, sometimes, formation of new bone, so that quite a cavity may be formed. Sarcoma of the dura will produce the same effect, and even pressure of blood-vessels within the dura seems to produce growths by atrophic processes. There is another form of excentric atrophy by which the external table disappears, at least in patches, leaving a very thin internal table. It is met with most often in the parietal region in the skulls of the elderly. It was first described by Lobstein and Rokitansky. It may be possible to recognize this condition in the living.

Even fever or an increasing hydrocephalus may produce an internal excentric anostosis. One cause which is supposed to lead to this condition is spontaneous separation of sutures, which can occur as the result of pressure in hydrocephalus. As a rule, it does not occur after the fifth year of life. In the literature of surgery there may be found numerous instances in which a spontaneous dehiscence of sutures has occurred. About its cause really nothing is known, although it would seem that it must be produced by increasing pressure of some kind.

Rhachitis of the Skull; Craniotabes.

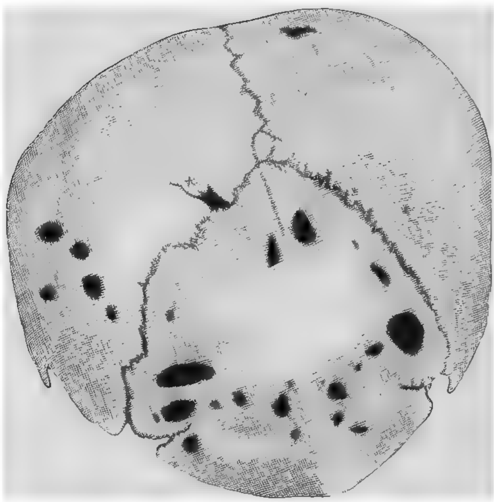
Rickets is universally recognized as a constitutional disturbance largely affecting the growth of the bone. It was Elsaesser[1] who in 1843 first adequately described rhachitis of the cranial bones, and who introduced the name "craniotabes." As a result of careful study it has been shown that when this condition is present the bone becomes unduly thick and its shape is altered. As a consequence of this and the inability to expand easily we have a flattened vertex with delayed ossification. The shape and size of the fontanelles are also characteristically altered. As the children grow the sutures become more and more firmly fastened together, while of late there has been a great deal of investigation concerning craniotabes as a cause of defective brain-development. Relatively speaking, the skull of the young is abnormally developed. So long as children do not leave the cot or are carried in the nurse's arms

[1] *Archiv f. Physiolog. Heilkunde*, 1848, vii. 295.

the pressure or weight of the head is borne upon the occipital region. Valentine has reckoned the weight of the new-born head as seven-twenty-fifths of the entire body-weight. The weight of the entire head, resting, therefore, continuously upon the occiput, must have a decided influence upon the shape of the growing skull.

The thickness of rickety cranial bones is frequently excessive, measuring 5 to 10 millimetres or more. Many rhachitic skulls show a number of small openings on either side of the middle line where the pericranium and dura come very close together, between them being

FIG. 403.



Craniotabes (rhachitis) (Bruns).

found a fine network of fibrous tissues. Irregular thickening may also occur at any point. Should doubt exist as to the nature of a given lesion, it may possibly be settled by comparing the anterior and posterior parts of the skull, as well as the appearance of the same. On account of continuous pressure of the brain on the posterior portion, marked signs of the convolution may be found on the inner side of the bone, while the effect upon the bones themselves is to press them deeper and make the posterior aspect of the skull much broader than the anterior. Similar changes are met with often at the base of the rhachitic skull. Irregular thickening, combined with atrophic areas and impressions or depressions made in the bone by the brain, are there met with. Perforation of the roof of the tympanum is occasionally seen. Kiesselbach has described a peculiar depression in the external table of the posterior temporal bone, and even in the external wall of the mastoid antrum, as a result of rhachitis.

The characteristic appearances of the facial bones are more easily recognized even than those of the skull, the former being relatively imperfectly developed. The question has been raised in many of these cases whether the influence secretly at work was not really syphilis instead of craniotabes. That the two may be combined there is no

reason to doubt, but that it is necessary to invoke the theory of syphilis to explain the ordinary rhachitic alterations of the skull is certainly not the case, although that hereditary syphilis may influence nutrition is well known.

An expanded vertex or back of the head is particularly seen in rhachitic children during the first or second years of life. When carefully examined it will be found that this abnormal arrangement is to be explained by reasons already given. A face of relatively normal magnitude may seem small when set off against an unnaturally enlarged skull posteriorly. In the normal skull the longitudinal diameter is only one-fifth to one-fourth greater than the transverse, while in the rhachitic skull this proportion is greatly altered. The symptoms of cranial rhachitis are the relative disproportions described above, slow development, the preponderance of the longitudinal diameter, slow closure of the large fontanelles, and softening of the posterior bones of the skull. The well-known systolic murmur heard over the large fontanelles, to which many have ascribed undue importance, can be heard in almost any child whose fontanelles are open. Along with these signs of craniotabes will almost always be found unmistakable signs of rhachitis in other parts of the body, particularly the bony skeleton.

Leontiasis.

This condition seems to have been first described by Tarin.[1] In his preface he states that Herodotus seems to have appreciated this condition among the Egyptians, while Avéado has reported in his *General History of India* that certain of the inhabitants had skulls so thick that the ordinary sabre would not penetrate them, but would be broken to pieces upon them. Cardamusta refers to the same condition among the inhabitants of the island of St. Thomas and other equatorial regions. There seems to have been a general suspicion that the heat of these regions made the cranial bones thick. Jonas found among these countries a skull so thick that he could not saw it. Welchius discovered skulls without sutures, whose bones were as thick as the little finger; and Keyslerus reports also specimens in the museum at Dresden in which the bone was as thick as a thumb. Malpighi was the first author who gave a complete description of hyperostosis of the skull. In 1799, Jadelot described a cranium of this character found at Rheims. Bojanus published a description of a similar cranium. In 1858, Huschke published in Jena an elaborate memoir on cranial and facial hyperostosis, with description of specimens.[2] One of the finest specimens in existence is that described by Gaddi,[3] to which Virchow has referred in his large work. To this condition he gave the name of "leontiasis," tracing a parallel between this condition of the bone and elephantiasis of the skin and connective tissue; and he speaks of the frequency of erysipelas in each form of disease. In 1879, Le Dentu[4] classified the cases previously recorded into three groups:

[1] *Ostéographie*, Paris, 1753.
[2] *Ueber Cranioslerosis Totalis Rhachitica*, Jena, 1858.
[3] *Iperostosi Scroful. Cerebr.-vertebral*, Modèna, 1864.
[4] *La Revue mensuelle de Méd. et de Chir.*, 1879.

A. Those in which the cranium alone is affected;
B. Those in which the face alone is affected; and
C. Those in which both are involved.

He rejected the name of "hyperostosis" for that of "diffuse periostosis." The best monograph on the subject is that by Baumgarten,[1] who has added a description of five more or less interesting specimens and the case-reports of thirteen patients whose cases were observed during life.

Etiology.—It is most interesting that with scarcely an exception the trouble extended over from twelve to sixteen years, there being only two known exceptions to this, one of which seems to have been rather a case of akromegaly, and the other to be an example of double osteoma of the upper jaws. Neither predisposing causes nor anything in the family history seems to have any bearing upon the known cases.

Signs and Symptoms.—The essential sign is deformity of the head as a result of thickening of the bones of the skull and irregularities produced on their surface by osseous deposits. This "leonine aspect," which led Virchow to give it the name by which it is generally known, is, in fact, a very excellent description of most of these cases, particularly of the cranium figured by Gaddi. The features and the appearance of the upper part of the head may be almost comically distorted, or the upper jaw may be so greatly hypertrophied as to give an unpleasant and repulsive appearance to the lower part of the face. In one or two instances the jaws have been so enormously developed as to cause the nose to almost sink out of sight. When the lower jaw also is involved the aspect given to the face is one of gigantic prognathism, and it is possible for the palatine vault to be considerably distorted. In the case of Bickersteth the deformity of the mouth was the cause of inanition and final death from starvation. When the affection extends, as it may possibly do, to the vertebral column, the upper portion of the body is given a gigantic appearance, which is almost indescribable, because the head becomes too heavy to be properly supported and the vertebral column yields gradually under the pressure. Some patients have suffered violent reflex headaches during the course of the disease, and occasionally epileptic crises have followed the violent headaches. These are confined rather to the earlier stages of the disease. The organs of special sense are more or less affected according as pressure is made on special nerves. This pressure may be also made upon the internal organs as well as upon the nerves—*e. g.* by obliteration of the orbit. Paralyses, epileptiform convulsions, mental disturbance, and paralytic dementia have been observed toward the conclusion of life in some of these individuals. These are accidents rather than usual results. Hyperostosis of the cranium seems to take place upward rather than inward; hence there is, as a rule, little or no cerebral compression, and the brain-symptoms are to be explained rather by disturbance of circulation than by permanent intracranial lesions. A condition of fair general health is quite compatible with the serious lesions above mentioned, and death is caused rather by gradual obliteration of the cavities of the face and of canals for vessels and nerves than by any direct internal pressure.

The **progress** of the disease is slow, but almost constant. Occasionally it is complicated by functional disturbance, such as amaurosis,

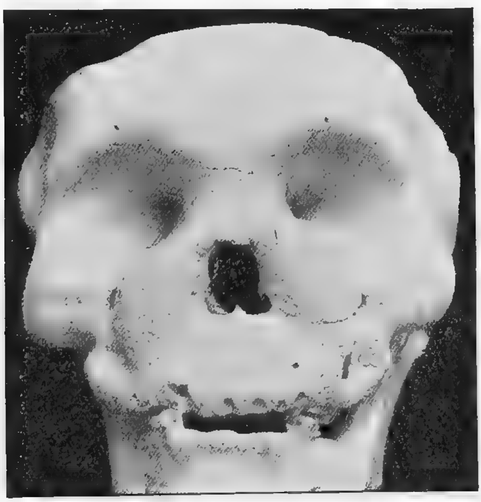
[1] *La Leontiasis Ossea*, Paris, 1892.

epileptiform attacks, etc. It is extremely slow, and death may not result for twenty or thirty years. There is reason to think that in some cases there has been a spontaneous arrest of the process.

Diagnosis.—Leontiasis may be confounded with the deforming ossific lesions described by Paget, usually known as "Paget's disease," as well as with akromegaly. Paget's disease is rare about the skull or face, and affects almost exclusively the long bones, especially at their joint-ends. It is practically never met with previous to the fortieth year of life, while leontiasis is an affection beginning in adolescence. Akromegaly has certain features in common with hyperostosis, since it begins at about the same time; but along with it go certain signs of functional disturbance of the brain, and particularly that increase in size and volume of the extremities which gives it its special name and which is totally lacking in leontiasis. In akromegaly such bony enlargements as occur are much more regular and even; in leontiasis these are very irregular and there is wide departure from any symmetry. The latter, moreover, is never accompanied by hypertrophy of the soft parts.[1]

Leontiasis may possibly be mistaken for tumor of one of the jaws. The former grows with exceeding slowness; the latter would probably

Fig. 404.



Leontiasis: skull of a Chinese woman (U. S. A. Museum, No. 10.620).

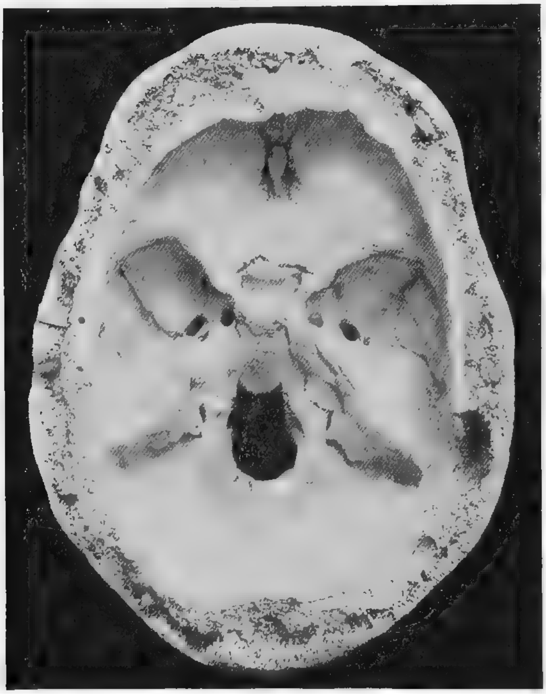
be of much more rapid development. Tumors are common; leontiasis extremely rare. Howship and Cooper have reported a case of double tumor of the upper jaws which might have been mistaken for leontiasis: these were bony, developed slowly, produce much deformity, but were essentially different. Osteoma of the jaw would affect only one part, while leontiasis would involve the entire extent.

Pathology.—The gross lesions which produce this appearance are constituted by an enormous augmentation of normal tissues, accompanied by more or less pain. In the cranium described by Gaddi the weight

[1] *Vide* Park, *International Med. Magazine*, June, 1895.

was seven times the normal, and in that described by Bojanus eight times the weight of the normal skull. In the latter instance the lower jaw attained a thickness of 67 millimetres; in the former, of 38. This new bone as it grows produces the obliteration of all the natural cavities

FIG. 405.



Base of same skull (Fig. 404).

of the part, as, for instance, the mouth, the nose, the orbits, etc. In the cranium proper the tables are widely separated, and the diploë contributes in large part to the thickening of the bones, its spongy texture becoming tense and hard, often like ivory. The foramina are obliterated or closed. The sella Turcica has been several times found enlarged and distorted, this lesion occurring also in akromegaly. Microscopical examination shows only the general appearance of condensing or rarefying ostitis.

These general osseous lesions have been described by Jadelot as an osteomalacia; by Gaddi, as scrofula; by Huschke, as rhachitis; and by Virchow, as the result of erysipelas. This diversity shows that none of the hypotheses so far advanced are tenable. We are at present unable to say more than that the morbid trophic influence begins to act during youth, and usually terminates only with the life of the individual. The mysterious and sluggish course of the disease prevents all hope of benefit from drugs, and its wide extent seems to preclude all possibility of beneficial surgical interference.

Hypertrophy of the Skull.

Under this term, or the still more vague title of "hyperostosis cranii," must be included a condition quite distinct from that of leontiasis, already described. This hypertrophy may be general or local; it may be concentric or diffuse or excentric. It is an even more local condition than leontiasis. There is in the Museum of the Royal College of Surgeons of London a remarkable example of true hypertrophy of every part of the skull. In structure the bones are normal, the thickening is uniform and symmetrical, and its only feature is osseous exaggeration. Of the causes which give rise to it nothing is known.[1]

In concentric hyperostosis the form of the skull is unchanged, but there is a great condensation of bone-tissue, so that the diploë becomes as compact as the outer surface, and the skull presents on section an ivory-like aspect; the sutures are usually obliterated. This is a condition most common in advanced life. Of its causes nothing is known; its recognition is impossible during life. The condition may be imitated in certain areas as the result of a chronic ostitis, but in such a case as that the surrounding bone-tissue shows evidence of inflammation.

An opposite condition is that of osteoporosis, noted in certain large thick skulls with sutures obliterated, whose bones appear on section uniform and porous, and, as Paget has said, very like white brick. A skull thus affected is much thickened, sometimes to four or five times its normal dimensions. This condition may result from ostitis deformans, osteomalacia, or from a peculiar manifestation of rickets.

Exostoses.

Closely connected with the manner of the growth of the skull, and at the same time inseparable from the tumors of the same, are the exostoses. They are spoken of as "exostoses" when they grow outward from the outer table; as "enostoses" when inward from the inner table; while those springing from the diploë have been spoken of as "parenchymatous exostoses." In structure they are ivory-like, compact, or cancellous, as the case may be. Of their causes nothing, or but little, is known. Just where to draw the line between a true hypertrophy and a true osteoma it is impossible to say. They are noted occasionally during pregnancy, and Hauff has reported the case of a woman in whom each succeeding pregnancy increased the size of a growth of this kind. Prolonged exanthemata of the scalp also figure as causes of these growths, in the estimation of Follin and Duplay. Most of them grow from the vault, particularly from the frontal. Next most often involved are the mastoid and the occipital regions. The tumors are often symmetrical. A few have been met with at the base of the skull. They may be single or multiple. They are variable in size: the largest are the cancellous tumors, especially those which spring from the bony sinuses. They grow slowly, may remain stationary, seldom cause much pain, but sometimes severe headache and pressure-symptoms. Lecat saw one patient die from compression caused by such tumor. Those near the orbit may

[1] Fischer, "Ueber Riesenwuchs," *Deutsche Zeitschft. f. Chirurgie,* xii. 1. Also, *Mittheilungen uus d. Chirurg. Klinik zu Breslau.*

grow into that cavity. The existence of enostoses can be suspected, but their exact character can only be proven upon autopsy or operation. External tumors of great size have been removed in time past, but, as these operations were formerly done in several sittings, sometimes of several hours each, with surgeons hammering and chiselling and repeatedly applying the trephine, they must have been barbarous in the extreme.

Acute Inflammations of the Cranial Bones.

PERIOSTITIS ACUTA CRANITIS; PERICRANITIS ACUTA.

Acute periostitis occurs often very early after injuries, and runs the same course here as elsewhere. It proceeds from the region of the wound, but may spread to a considerable extent and depth, or it may occur apparently spontaneously. In this case it is due to the same causes which determine similar lesions elsewhere. It has been known to occur after most of the acute infectious diseases. It is most frequent in the region posterior to the ear and about the mastoid cells, where suppuration often takes place. Inflammation may also often travel outward from these cells, and pus may penetrate to a considerable distance beneath this membrane. Frequently congenital openings or defects of the masto-squamous sutures have much to do with determining the direction of these lesions. Pericranitis leads very commonly to suppuration. When under these circumstances pus forms there is a fair prospect of reapplication of the membrane to the bone, provided evacuation be early practised; otherwise there may follow superficial caries.

Exact diagnosis as between phlegmon of the scalp, periostitis, and osteomyelitis is not always easy. However, in either case there is good reason for early and free incision.[1]

CHRONIC PERIOSTITIS OR PERICRANITIS.

This for the most part assumes the form of an ossifying lesion. Nevertheless, cold abscesses involving the pericranium are not rare, and there is a well-known pericranitis gummosa, the result of old syphilitic affection, which is for the most part accompanied by similar disease of the underlying bone. As the result of certain ossifying forms we have formation of osteophytes, which are seen sometimes among pregnant tubercular women and among chronic drinkers. Chronic suppurative pericranitis is the result almost entirely of tubercular disease, and results in the formation of cold abscesses. Its proceeds most often from the mastoid cells, but sometimes from the frontal sinus or other point. It is seen most often in cachectic children. There is often a history of trifling injury, which leads first to hemorrhage and then to subperiosteal abscess. There is frequently formation of osseous nodules in the periosteum which can be moved over the underlying bone. As the case becomes chronic these become fixed and finally inseparable, while more bony material is deposited about them. The cold abscesses tend to evacuate themselves in the course of time, with more or less destruction of tissue if not prop-

[1] *Vide* Gangolphe, *Maladies infectieuses et parasitaires des Os;* also, Ulmann, *Beitrag zur Lehre des Osteomyelitis acuta.*

erly cared for. There result frequently sinuses leading down to carious or necrotic bone. Often in children, sometimes in adults, there will be found actual perforation of the bone, so that the membranes beneath are exposed during the necessary operation. It has occurred to the writer, for instance, to find at least seven or eight of these in one case. When attacked, operation should be so thoroughly made that all suspicious and tubercular granulations are scraped away and their bases cauterized with zinc chloride.

ACUTE OSTEOMYELITIS; CRANITIS ACUTA.

This occurs most frequently after injury; it is rarely spontaneous. When apparently idiopathic it is usually the extension of destructive processes from some neighboring point, particularly the middle ear. It has been known to occur after the removal of a small area of periosteum required by a rhinoplastic operation. As a rule, it does not occur immediately after injury, there being an interval of from ten to fourteen days, during which the wound may appear to be granulating, when suddenly there is accession of fever, with chills, etc. Now the pericranium will be found loosened, and in the depth of the wound some collection of pus, which is often of the greenish hue produced by the bacillus pyocyaneus, the appearance of this organism indicating at least a tardy convalesence if nothing more disastrous. Not infrequently this condition may lead to general pyæmic infection, permitted by the proximity of the diploëtic veins. Then the clinical picture before us is usually one of sinus-phlebitis, and the first serious symptom may be a violent chill. On the very first suspicion of swelling, tenderness, suppuration, or even œdema of the local parts there should be such speedy attention to the condition as to, if possible, prevent the occurrence of deeper lesions. That destruction of bone from such disease may be extensive is proven by, *e. g.*, an instance reported by Dupuytren, who saw the entire vertex of the skull involved after a diffuse phlegmon.

Pathologically speaking, these cases are for the most part an osteomyelitis of the diploë. On section the spongy tissue of its structure will be found saturated with pus and products of degeneration of bone-marrow. Usually these will have a distinctly greenish tint. Sometimes there is a distinct collection of pus between the bone and the dura, as Dupuytren and Pott long ago indicated. As a rule, however, the inner surface of the bone is not bathed in pus. The veins of the diploë play a very prominent rôle, and will be found filled with breaking-down thrombi. When these, as is too often the case, empty their contents into the internal sinuses, there is practically no chance for the patient's life. In this light it is perhaps fortunate when the dura is separated from the bone by pus, since this emptying of the diploëtic veins is then less likely to occur. Osteomyelitis, therefore, here as in other spongy bones, occurs as another expression of the ease with which a true embolic and metastatic pyæmic disturbance can be set up.

The **prognosis** is for the most part unfavorable, but will depend in large measure on what can be accomplished by treatment. This must be extensive incision and exposure of the diseased parts, which means the use not only of the scalpel, but of the chisel, trephine, and other bone

instruments. Here, as elsewhere, one may say that the surgeon's instruments judiciously used will do less harm than pus allowed to take its own course and travel more deeply.

Aside from exposure and removal of bone, the **treatment** of these cases is practically the same as that of sinus-phlebitis, to which the reader is referred. It all may be summed up in the advice to expose mercilessly the focus of disease over its entire extent, to remove necrotic tissue, to disinfect thoroughly, to cauterize freely with zinc-chloride solution, 50 per cent. The writer advises to irrigate well after using this caustic, since in one case experience taught Thiersch its capability of acting through the entire thickness of an average skull and affecting the parts beneath. In Thiersch's case, however, he had to deal with cancellous bone, which probably was less resistant and more porous than ordinarily is the case.[1]

CHRONIC OSTITIS; CRANITIS CHRONICA.

This condition may develop from exposure or injury of the cranial bones. Spongy granulations proliferate, among which little fragments of the external table die and are extruded. The condition may last for a long time and healing be tedious. In most cases, however, there is a peculiar cause, either constitutional syphilis or tubercular disease. It is possible also for suppurative degeneration to extend down to the bone; and this is most common in the temporal region and the neighborhood of the middle ear. The tuberculous character of most cases of cranial caries has only comparatively recently been generally recognized. It seems to be preceded by concealed formation of granulation tissue in the diploë, which leads first to cancellous degeneration, as a result of which the overlying bone dies, while the surrounding parts participate more or less in the process. When a sequestrum forms it is usually of the entire thickness of the bone. It is sometimes separated spontaneously, a granulating dura being thus exposed. The petrosal and mastoid portions of the temporal are most frequently involved in this process. These lesions may be multiple, and Socin and others in cases of multiple caries have found that a tubercular meningitis had been produced by extension.

It often happens that the first **symptoms** of caries are the occurrence of fluctuating tumor, either from a breaking-down gumma or a cold abscess, and that if this be incised one comes at once upon exposed bone. In some of these cases there will be headache and tenderness, from which other cases will be quite free. In most extradural collections of pus severe symptoms are provoked.

Calender has reported the case of a ten-year-old boy who complained of pain and somnolence: after ten days an abscess appeared on the right temple, after whose spontaneous evacuation a sequestrum was isolated which involved the entire thickness of the underlying bone. When the dura is thus exposed brain-pulsations are visible and are augmented by deep respiration. In other instances abscesses connected with perforation have been known to pulsate externally.

Parts adjacent are likely to suffer from complications; thus, when the temporal is involved hearing will be usually compromised. There may

[1] *Vide* Albert, "Cranial Osteomyelitis," *The Medical Week*, 1894, vol. ii., No. 50.

be also involvement of special nerves. By proximity of some large vessel there may be serious or fatal hemorrhage. This danger is greatest in the

FIG. 406.

Caries with perforation and osteosclerosis (Bruns).

direction of the transverse sinus and the internal carotid. In temporal caries, however, the greatest danger is with reference to extension along the dura to the sinuses, and even to the brain.

The **treatment** for caries is practically operative, although when due to syphilis there is urgent need for specific medication as well.

GANGRENE OF THE BONE; NECROSIS.

Necrosis of the skull is seldom met with except as above or as a direct or indirect result of injury. It may follow a violent separation of the bone, especially when this has not been cleanly and exactly reapplied. If bone has been so exposed as to become dry by evaporation, it is very likely to undergo necrosis. Such necrosis, however, is usually confined to the external table. Saviard has reported a case where two years after a blow the entire vertex of the skull, corresponding to the portion ordinarily removed upon autopsy, became necrotic and separated of itself.

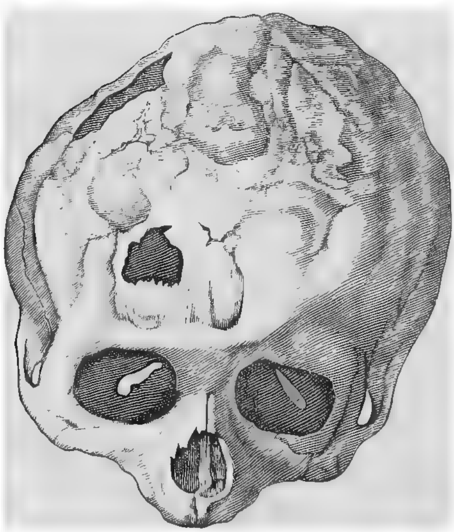
After severe burns of the scalp, such as are observed in children, we frequently have necrosis of the outer table. Should the heat have been very great, the entire thickness of the bone may die. In one case, reported by Kirkead, there separated from the skull of a seventy-year-old paretic woman a piece of bone seven inches long and five inches wide, leaving the dura exposed and granulating to this extent.

Broca has reported the case of a child who lost three-fourths of the surface of his skull by necrosis following a burn. In necrosis of the

FIG. 407.

Recovery after extensive necrosis and loss of bone (Bruns).

FIG. 408.



Caries and necrosis of cranium (Bruns).

internal table, which is relatively very rare, Nature makes efforts to extrude the sequestrum by a slow process of granulation and liquefaction of overlying bone.

Brotherston extracted from a frontal bone a sequestrum which had been fifteen years endeavoring to separate itself. The sequestra most easily separable are those due to tubercular disease. It is the peculiarity of all cases of cranial necrosis that here the sequestrum is not surrounded by bony new formation, as is customary in the other bones of the skeleton, there being no reduplication of the skull or parts adjacent to the lesion. There may be met with a thickening of the surrounding bone, but nothing like the real formation which accompanies necrosis elsewhere.

Injuries to the Head Previous to Birth.

The fœtal head *in utero*, surrounded by amniotic fluid, is shielded from most injuries. Particularly during the later months of pregnancy it is protected by the position which it usually occupies behind the pubis. Of course wounds penetrating through the abdominal walls of the mother into the uterus may at the same time injure the fœtus, and it is possible that such injuries occur oftener than is generally reported. That even without penetrating wounds or without perceptible injury, or at least with only trifling external lesion, the head of the fœtus may be injured is evidenced by many recorded cases. For instance, Dieterich[1] saw a new-born girl upon both sides of whose head there was a loss of substance, the defect being filled with granulation tissue and showing cicatricial tissue around the borders. Both forearms were broken and callus could be perceived in each arm. The mother had fallen two weeks before her delivery. Abele[2] reported the case of a woman thrown to the ground by a cow, whose foot injured her abdomen. Some weeks later she bore a child with a long wound upon the forehead, which was suppurating. Tarnier[3] reported to the Paris Society of Surgery a one-day-old child with a well-marked scar upon the side of the head.

Many cases of skull-fracture have been reported as occurring before birth, which doubtless really occurred during delivery. Maschka[4] has reported the case of a young woman in the eighth month of pregnancy who fell from the second story, broke both thighs, and died in six hours. The fœtus within the uterus showed multiple fractures of the skull as well as blood-clot inside and outside the bone. Blot[5] reports a woman falling considerable distance during her first confinement and sustaining severe contusions and fracture of the thigh. The child's head revealed crepitation at many points, and investigation showed that both parietal bones were broken. The child died, but the mother lived.

The question whether the mother's parts themselves can participate in injury to the fœtus, so that injuries to the skull can occur, is perhaps still open. That extravasations of blood or depressions produced by pressure of the mother's parts, such as exostoses from the vertebræ or pelvis, may injure the skull, there can be no doubt. There is, for instance, a specimen in the St. Petersburg Collection, reported by Bidder—

[1] *Württem. Med. Corresblatt.*, 1838, vol. viii. p. 5. [2] *Ibid.*, vol. v. p. 1.
[3] *Un. Méd.*, 1872, No. 33. [4] *Prag. Vierteljahresschrift*, 1856, vol. iv., p. 105.
[5] *Bull. de l'Acad. Royale de Méd.*, Paris, 1847–48, p. 1032.

a fœtus of seven months with a long, deep depression along the sagittal suture, in which one of the feet had rested. There are many other specimens in existence which lead one to think that the pressure of the feet may work serious injury to the head.

Injuries to the Head during Birth.

BLOODY TUMORS OF THE NEW-BORN; CAPUT SUCCEDANEUM.

No matter what the presentation, there always appears at the point where pressure has been least a tumor of the scalp in the new-born, ordinarily known as "caput succedaneum," which usually quickly disappears after birth. It is in most instances an expression of the fact of minimum pressure at this point. While in one sense the pressure upon the fœtal body is everywhere the same, partly because of the amniotic fluid in which it lies, this condition is altered during delivery, and that portion presenting at the os is relieved of most of the surrounding pressure. When delivery occurs with unruptured membranes this tumor is reduced to a minimum, except when there are disproportions between the size of the head and that of the pelvis. In very narrow pelves the head may be forced into the pelvis in such a way that at the engaged portion pressure upon the veins is very much increased. That in these instances the cranial bones are not surprisingly compressed is remarkable. In normal pelves the formation of caput succedaneum only occurs when the greatest diameter of the fœtal head engages in the pelvic strait; in other words, where the presentation is frontal.

This tumor consists practically of œdema of the soft parts outside the skull. If incised, there pours out a rich yellowish fluid, mainly serum stained with blood. When the large vessels are ruptured we have ecchymoses of the skin. These are so frequent that it is often possible to diagnose the presentation by the appearance of the infant's head. Carefully examined, there are often found thin extravasations outside or beneath the pericranium. After delivery, as the equilibrium of circulation is regained, these tumors ordinarily quickly vanish. Sometimes they change in location, and, as infants rest for the most part upon the back, the œdema may shift to the occipital region. These tumors usually disappear by the third or fourth day.

CONTUSION OF THE SCALP.

In narrow pelves, especially with projecting promontory, the new-born head may show more or less contusion of the soft parts, consisting for the most part of limited infiltrations, which usually quickly vanish, but which may go on even to gangrene of the skin, which may be indicated even later in life by cicatricial areas over which the hair does not grow. Sometimes these lesions are followed by acute phlegmons, and the little patients die therefrom. The results of the application of forceps are quite similar, only they are ordinarily quite distinctive. They are usually double, one opposite the other. It has been known that fatal septic inflammation has resulted from injuries to the head produced by forceps.

CEPHALHÆMATOMA OF THE NEW-BORN; THROMBUS NEONATORUM.

A tumor-like collection of fluid blood between the pericranium and the bone of the new-born skull is known as "cephalhæmatoma neonatorum." These have been divided into the epicranial and the subaponeurotic, the latter being the rarer. These lesions occur on an average once in two hundred cases. About the same causes come into play as in the lesions mentioned above, the most common one being direct pressure. These lesions are also found directly over the fissures, where they may be caused by sliding of the bones. Termin has described a typical cephalhæmatoma overlying a fracture of the new-born skull. Bergmann refers to similar conditions due to pressure of the mother's parts. In one case he found hemorrhage both inside and outside the pericranium, the underlying bones being fissured. Coincidence of such lesions with intracranial hemorrhages has been noticed by Rokitansky and others, while Scheglow[1] has described four such cases. Most of the blood thus poured out escapes as the result of vascular injuries occurring during delivery. This may continue during the first few hours after birth. If this blood is not quickly absorbed, there will appear after a few hours a consistent tumor surrounded by a circular border on a different level, so that on palpation the impression given to the finger is as if the skull had been depressed over this area. Inside of this ring the tumor may be elastic and even fluctuating. Some have described this ring as occurring so early as the second day; others, not until the second week. Numerous preparations in existence make it plain that this zone of hardened tissue is the elevated periosteum, which has gone on rapidly toward partial or complete ossification, and proceeds toward the centre in isolated patches resembling small Wormian bones.

Diagnosis is easy. It is necessary mainly to distinguish only from encephalocele. Le Dran once mistook a cephalhæmatoma for a hernia cerebri, the bony ring being so prominent as to be mistaken for an opening in the skull. As elsewhere noted, encephaloceles are most common near the middle line, while cephalhæmatomata are most common in the parietal regions. Such formations of new bone are, however, not constant: the effused blood may vanish within three to ten days, after which the pericranium becomes reattached. These bloody tumors also may suppurate, infection occurring from some slight abrasion or lesion of the neighboring skin. If pus replace blood, we have, of course, an abscess. Even if this be subperiosteal, after free incision and cleansing the periosteum will usually reapply itself. St. Germain has related a case of gangrene of the skin over a cephalhæmatoma with necrosis of the underlying bone, so that several fragments were removed, causing later prolapse of the brain and finally death of the child.

The **treatment** of these lesions should be confined for the most part to prevention of suppurative inflammation. If this be done, the blood will usually disappear spontaneously. Dieffenbach and others have recommended free incision, but it is for the most part unnecessary. An uninflamed tumor of this kind is better left alone. Even when it is necessary to remove its contents, it is often best to do this by aspiration

[1] *Materialien z. path. Anat. des Cephalhæmatoms, etc.* [Russian], 1876, p. 35.

rather than by incision. The latter can only be called for when suppuration has occurred.

This subject cannot be dismissed without brief reference to the occasional occurrence of icterus in these cases. The jaundice is usually mild and appears to be of the hæmatogenous variety; in other words, to be due to resorption of the extravasation. Discolorations of the sclera and the skin are occasionally noticed, and also in the urine there may be found, on proper tests, biliary coloring matter.

DISPLACEMENTS OF THE CRANIAL BONES.

In the fœtal head the cranial bones are easily displaced. As the result of pressure during delivery the shape and size of the head are materially altered. Within ordinary limits the process is a physiological one. Occasionally, however, it passes beyond this degree and becomes pathological. Obstetricians have described a more or less regular method of displacement, varying with the presentation. In the common occipital presentations the occipital bone is pushed beneath the parietals. In the average narrow pelvis the temporal bone comes in contact with the sacral promontory, and is usually displaced. Fritsch has described the case of a boy of twelve who presented remarkable deformity of the skull, due to the fact that in the mother's pelvis the conjugate diameter was only ten centimetres; and there can be no question but that the asymmetry of many skulls is to be explained in this way. This will also explain that kind of oblique shape of the skull in which one oblique diameter is very different from the other. It has been claimed that the peculiar dolichocephalic form of certain skulls is due to face presentation.

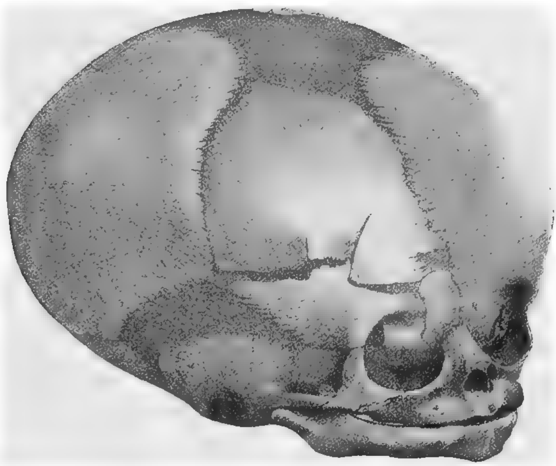
DISTORTIONS, FISSURES, AND FRACTURES OF THE CRANIAL BONES.

When we remember the tremendous pressure to which the fœtal skull is subjected, it is not strange that its form or shape is affected in passing through the pelvis, and thus it may happen that certain of the cranial bones are flattened or warped to a large extent. Bergmann and others have described certain more or less common alterations due to pressure from the promontory and to other causes.

The **prognosis** of distinct depressions is bad. Schroeder found that of 65 children born with this defect, 22 were dead at, and 10 died soon after, birth, and that only 33 lived for any length of time. The causes of death were for the most part intracranial hemorrhage with consequent asphyxiation from pressure. It, moreover, happens that many of these children who live to grow up develop epilepsy or other cerebral lesions. Bergmann has reported the case of a girl of fourteen whose mother's pelvis was so narrow that forceps were used for a long time, and who presented a deep funnel-shaped depression of the occipital with abrupt edges; the overlying skin had become gangrenous and tedious suppuration had followed its separation. There was a depression at least a centimetre deep close to the superior curved line, covered with adherent and bald skin. This child had suffered from epileptiform convulsions for three years. The case is of interest, since it shows the result of early depression on the later life of the individual, and teaches the wisdom of early remedy of such defects. In early times these injuries were of more frequent

occurrence than of late, largely because of the improvement in the shape and handling of forceps. Michaelis has given the history of one woman with narrow pelvis whose first and second children were born with broken skulls because of it, while the third survived. In a skull in the museum at Halle the disastrous effects of forceps-pressure are shown by fractures of the left frontal and right occipital. Fritsch has pictured a case where in delivery by the feet the temporal bone of a child was broken into fragments. It occurred during version and rapid delivery because of rupture of the uterus. With flattening of the parietal bone occur often small fissures and solutions of continuity radiating from the parietal prominence.

FIG. 409.



Fracture of right frontal bone in a new-born infant; fracture extending into orbit (Bruns).

Defects of ossification are not entirely spontaneous, but may be due to the direct results of injury. They may, moreover, be often mistaken for the results of fracture. This may be of medico-legal import, since numerous defects have been mistaken for injuries, and *vice versâ*. In certain cases of very incomplete osteogenesis the skull has acted as if broken into numerous fragments. Careful study of such a case will ensure its proper appreciation and the avoidance of error. (*Vide* "Aplasia Cranii.") Violent separation of sutures occurs most often at the vertex. Thus, one parietal bone may be pressed so deeply inward as to completely separate it from its fellow. Separation of the temporal and parietal bones is most common in delivery after podalic version. A very rare injury occurring in some of these cases is a separation of the condyloid processes from the occipital bone proper. This is known to occur frequently when the skull of the dead fœtus is crushed in order to facilitate delivery. It is known also to occur in delivery after podalic version. Winckel found it once after a normal presentation, and Schroeder reports it as occurring twice after difficult deliveries.

Treatment of Depressions in the Skull of the New-born.—In the ordinary text-books the conditions above described have been al-

luded to as most unsatisfactory to treat. It has been held by many that these depressions come right of themselves, the natural resiliency of the bone and the intracranial pressure being supposed to effect all that is necessary. There are certainly some cases on record which justify this view, and yet the very fact that a number of most unfortunate results have been the consequence of delay should make us ready to interfere, if necessary, very early. The neurologists and surgeons of to-day see numerous cases of hemiplegia or other cerebral lesions due to injuries occurring at birth which have failed to be rectified by natural processes. Fritsch has regarded these cases as generally fatal, since even if the child cries lustily at birth, it usually becomes drowsy in a few hours and dies of stupor. Schroeder has advised immediate operation, especially if there are symptoms. He recommends first pneumatic traction; this failing, trephining, which *per se* is not dangerous. He believes in operating on nearly every case of frontal depressions, since these less often right themselves. Jennings[1] has made a strong plea for immediate operation, and reports four cases by himself and other operators in which it was done within a day or two after birth for depressions, and in every case with success. McKennan[2] has reported depression of the skull with the child comatose and barely alive. The depression was over the frontal region. Incision was made, and the bone elevated after using the small trephine. Then the button was replaced and the wound dressed. In five minutes the child opened one eye; in an hour it cried; and it made eventually a perfect recovery.

Smith reports the case of a boy five and a half years old with spastic contractures and paralyses of the arms and legs, unable to stand, intelligent, but scarcely able to articulate. Symptoms present from birth. Transverse depression of occipital bone, two and a quarter inches wide, found just below the occipital protuberance. Two openings were made in the depressed bone by means of a one-inch trephine; these were united into one. The meninges projected forcibly, showing relief of tension. Wound healed *per primum*. Marked improvement at once in child's general condition. Gradual relaxation of limbs with continuous improvement and quiet sleep.[3]

There is then ample published evidence to warrant the performance of early operation in every case that does not promise well for natural methods, while at the same time the knowledge of what the future may bring to these cases the more urgently demands such legitimate interference.

Points in the Surgical Anatomy of the Skull.[4]

Before going further in the subject of injuries or diseases of the skull and its contents, this appears to be an appropriate place to introduce some remarks upon regional and surgical anatomy not met with in the ordinary text-books, and of the greatest importance to the surgeon. The information given herewith may not be applicable in the imme-

[1] *Med. Record*, 1894, vol. xlvi. p. 166.
[2] *Pitts. Med. Review*, 1894, vol. viii. p. 125. [3] *Lancet*, 1894, No. 3700, p. 193.
[4] The writer acknowledges his indebtedness to the work of Macewen on *Infectious Diseases of the Brain* in the preparation of much of this section.

diately ensuing pages, since it pertains in a measure to the regional directions necessary to observe in operations for deep abscesses, etc.

The masto-squamosal suture marks the lower and posterior limit of the squamous bone, where it forms the outer wall of the mastoid antrum. Operative measures confined to this plate, and not penetrating through it to the petrous bone or to the inner wall of the antrum, are safe from injuring the aqueduct of Fallopius or the sigmoid sinus. The petro-squamosal sinus is practically a fœtal structure, which, however, persists through life in a certain proportion of cases. The ridge formed by the posterior root of the zygoma indicates by its lower border the level of the mastoid antrum. A few lines above this is the level of the base of the brain. The posterior portion of the mastoid antrum may be freely exposed so far as its outer covering—*i. e.* the descending plate of the squamous—descends; but if one penetrates deeply, he will expose the sigmoid groove by entering the mastoid in a backward and inward direction.

The mastoid is present at birth, and becomes externally palpable by the second year. The antrum is found at birth, though its air-cells do not develop until after puberty, their location being previously occupied by cancellous tissue. Most of the cells open into the antrum, a few directly into the tympanum. The upper layers of these cells have membrane projecting into them from the antrum. They usually communicate, but a thin partition of bone separates them from the sigmoid groove. Occasionally this is defective, the wall of the sinus being then separated only by a fibrous membrane; even this is sometimes lacking. This partition is perforated by minute veins, forming a communication between the sinus and the antrum. Occasionally the mastoid is double. In some animals it remains quite separate, and it has even been found separate in the human skull. Air escaping from the mastoid cells into the overlying tissue may cause emphysema after a basal fracture.

Fractures of the petrous bone involving the carotid canal have been known to cause rupture of the carotid artery, with fatal extravasation. By caries of this canal with erosion thrombosis of the artery has been produced.

The mastoid antrum lies behind the facial canal, descending in a line with the passage between the tympanum and the antrum to its inner side. In order to avoid injuring this during operation, one should keep to the outer wall of the antrum. The descending or mastoid portion of this facial canal lies at a variable distance from the outer surface of the mastoid. Therefore, in exposing the antrum the higher and the closer to the posterior zygomatic ridge the opening is made the more surely will the facial nerve escape injury. As the tympanic cavity is sometimes exposed, it is well to remember that the bend between the two portions of the facial nerve lies above the fenestra ovalis.

The sigmoid groove extends to the jugular foramen from a point on the outside corresponding to the asterion. Its knee—that is, its anterior convexity—is favorable in location, but is generally found on a level with the upper part of the external bony meatus. The groove on the right side is generally wider and deeper, projecting more outward and advancing more forward, than that on the left. This may account for the alleged greater frequency of intracranial sequelæ following otitis

media on the right side. The lateral sinus may be indicated externally by a line from the superior border of the mastoid apophysis to the inion, or from the asterion to the inion. It is usually convex upward.

In differentiating between paralysis of the facial muscles due to a nerve-lesion and that due to a central lesion, the former is much more complete. In the latter, patients are generally able to close their eyelids voluntarily, and they retain some degree of emotional expression, without loss of taste in the anterior two-thirds of the tongue. Stimulation of the chorda in the tympanum causes prickling in the tip of the tongue, while its destruction is followed by a unilateral loss of taste in the anterior two-thirds. Stimulation of one labyrinth affects the semicircular canals in both ears. Violent injection of fluid into a rabbit's ear causes vertigo, nystagmus, and rotation of the head. These canals may be compressed by granulation tissue, after the removal of which symptoms may disappear. A hard plug of wax pressing on the membrane may cause severe giddiness in the same way. Possibility of this kind of irritation should always be eliminated, in supposed cerebral abscesses, by examination of the ears, since giddiness and vomiting may thus be caused.

The frontal sinuses are usually separated by a septum which is often incomplete and occasionally wanting. The sinuses are variable in size and irregular in outline. They are seldom met with before the seventh year. In some cases they are capable of holding two ounces of fluid. When attacked by inflammation their lining membrane, especially that of the infundibulum, swells, and exit of fluid is thus interfered with, accumulation and retention ensuing. The retained secretion escapes when inflammation subsides, but recurrence of empyema is quite possible. By ulceration and erosion escape may occur at the weakest point, usually on the supraorbital plates, so that pus may penetrate through the inner half of the orbit. These cases are generally seen in ophthalmic practice. Spontaneous perforation follows this route in about 90 per cent. of cases. Perforation may occur through the posterior wall of the frontal sinus, and pachymeningitis ensue, or the interior may be invaded and leptomeningitis or cerebral abscess result.

THE VENOUS CIRCULATION.

One of the largest of the cerebral veins is the middle cerebral, which enters the great cavernous sinus at the lower end of the Sylvian fissure. The Sylvian vein, the great anastomotic, runs forward in the posterior arm of the fissure, and collects blood from the surface of the parietal lobe to connect with the upper cerebral veins. It perforates the dura near the lesser wing of the sphenoid, passes backward in the middle fossa, communicates with the middle meningeal veins, and empties into the superior petrosal sinus. These are the two venous channels by which blood from the longitudinal sinus may communicate with the basal sinuses. Several of the cerebral vessels have direct channels which communicate with the middle meningeal veins. The veins of the corpus striatum and the ventricles pass directly in the venæ magnæ Galeni, opening into the straight sinus. In the motor area there are two principal veins—one, the great superior cerebral, running in the pre-Rolandic sulcus and occasionally in the Rolandic fissure, communicating

directly between the longitudinal sinus and the Sylvian vein; the other, smaller in size, runs parallel to this in the post-Rolandic fissure, serving the same purpose.

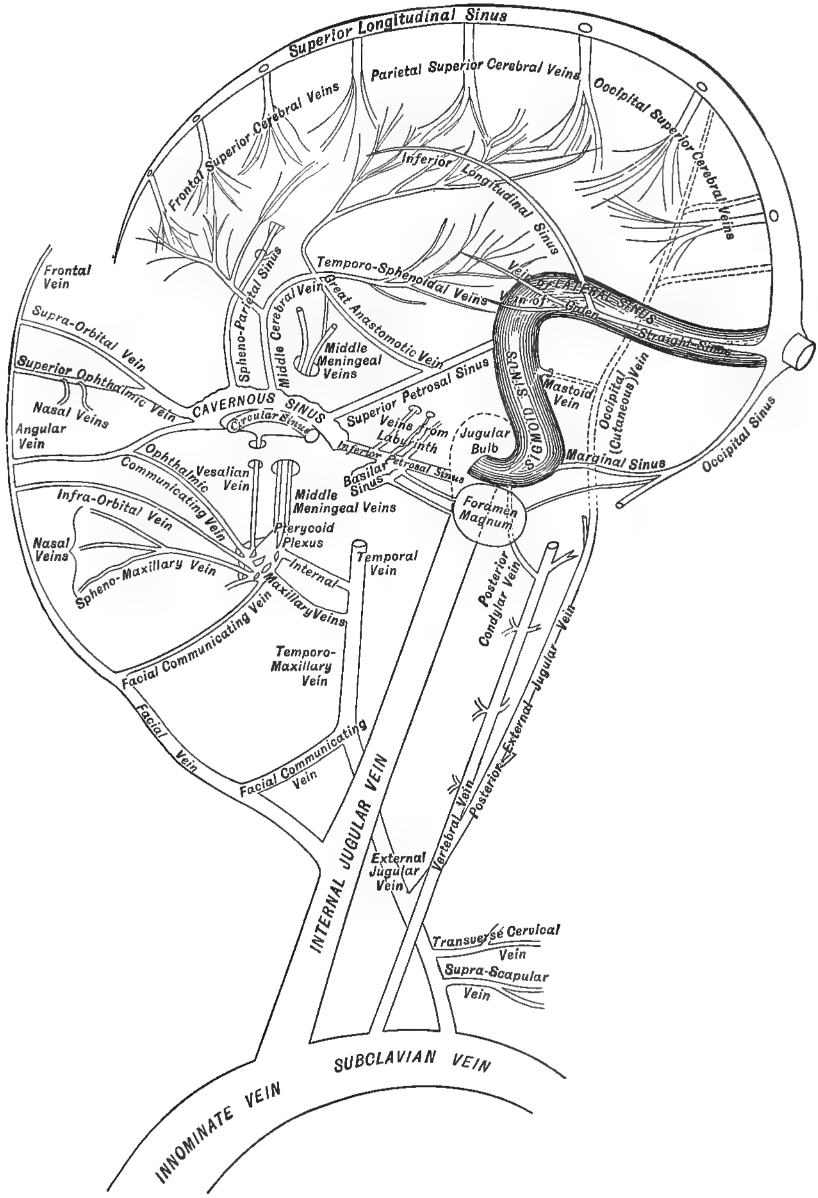
The frontal and diploëtic veins from the parietal pass into the longitudinal sinus, forming dilatations as they enter. Marasmic thrombosis of the longitudinal sinus quite often originates in these dilatations. They connect also with the middle meningeal veins, and consequently form anastomoses between the above sinus and the pterygoid plexus, which empties into the internal maxillary and deep facial. The longitudinal sinus is also connected with the veins of the nasal septum by a small vein penetrating the foramen cæcum. In this way infective organisms may enter the sinus through the nose.

The sigmoid sinus is the name given to that portion of the lateral which is contained in the sigmoid groove. These grooves are usually asymmetrical, that of the right side being the larger. The right lateral sinus generally receives the bulk of the blood from the superior longitudinal, and the left lateral that from the straight sinus. The sigmoid connects directly with the exterior through the mastoid and the posterior condyloid veins. These are of considerable importance surgically and clinically, although neither of them is very constant. If thrombosis occur in the sigmoid sinus, the mastoid vein is usually likewise affected. But, unless the thrombus extends through the thickness of the skull, it cannot be observed during life, as the large vein which it joins on the outside of the cranium continues open and of normal size. Pus is known to collect in the sigmoid groove outside the sinus, work its way along this vein, and form an abscess on the exterior of the skull, opening in the upper part of the neck; or, on the other hand, the mastoid vein has been completely distended with thrombi. If so filled, the mastoid canal will leave little room for the exit of pus. When pus does escape by this path, there must exist an extradural collection from the sigmoid groove, and the probability is that the sinus itself is filled with thrombus. This would be the more probable if the mastoid vein is found similarly filled. The posterior condyloid foramen is occupied by a vein which connects the sigmoid sinus with the deep veins at the back of the neck and with the vertebral plexuses; hence, when the posterior aspect of the petrous bone is covered with pus accompanying suppurative thrombosis of the sigmoid sinus, this foramen offers facilities for the drainage of the posterior fossa to the outside of the skull; and when this occurs the cellular tissue of the posterior cervical triangle may become inflamed and extensive deep abscess may form secondarily to the internal suppuration. There is often inflammatory tenderness in this region short of abscess. This tenderness is also a sequel of pachymeningitis in the cerebellar fossa, and frequently accompanies inflammatory thrombosis of the internal jugular.

There is also an anterior condyloid vein, or several of them, accompanying the hypoglossal nerve; and in cases of purulent leptomeningitis the anterior condyloid foramen may serve for the exit of pus or the entrance of micro-organisms.

Though the internal jugular is the main channel through which infective matter is carried from a thrombosis in any part of the lateral or sigmoid sinus, yet it may also be carried by way of the posterior condy-

Fig. 410.



Schema of the cerebral veins and sinuses (from Macewen).

loid, the mastoid veins, or the occipital sinus, all of which pour their contents directly into the subclavian without passing through the internal jugular.

These sinuses are all rigid, non-collapsable tubes, always patent, while

the veins are thin, delicate, and flexible, their calibre during life varying constantly with inspiration and expiration from a state of almost complete collapse to one of great distention. The whole intracranial arrangement is calculated to ensure that which the cervical arrangement of the veins would never permit—*i. e.* an even, regular flow of blood without fluctuation, produced by the suction or aspiration of the respiratory movements. The special mechanism by which the aspiration of venous blood from the brain is not permitted is not necessary during fœtal life, when there are no lung-movements; consequently, during fœtal life we find that the lateral sinus pours its blood into the petro-squamosal sinus, that is later either obliterated or represented only by a small vein, and this in turn empties into the external jugular vein.

LYMPHATICS.

Those for the scalp pass into the occipital, mastoid, and parotid lymph-nodes, while those for the forehead join the facial vessels. The intracranial lymphatics have their origin in the cerebral pia and in the choroid plexuses, and pass out of the cranium along the internal carotid and vertebral and the internal jugular to the deep cervical lymph-nodes. A few pass along from the choroid plexuses and accompany the veins of Galen. The superficial nodes lie along the external jugular between the platysma and the deep fascia. Into these empty all the lymphatics for the external regions of the skull, and in these extracranial lesions will first show themselves by enlargement. If this persist, the deep cervical will also participate. Intracranial infection shows itself in swelling of the deep cervicals, which, concealed under the deep fascia, are more difficult of recognition. By cervical adenopathy meningeal lesions cannot be differentiated from cerebral nor from sigmoid thrombosis, nor can any very valuable information be gleaned as to the exact locality involved. Nevertheless, enlargement of the lymphatics should always be looked for. Sometimes in suppurative meningitis of the posterior fossa the suboccipital glands are involved.

MEMBRANES.

In the dura lymphatics are abundant. They arise from spaces which serve for the passage of lymph, and which can be injected from the epidural space, where this exists. In the cranium the injecting fluid can be forced along them through the thickness of the dura into this space. This shows how this space communicates with the lymph-system and with the dural veins. Hence, pathogenic organisms, once harbored within the dura, find it easily opened to invasion.

The dura is much more adherent at some parts of the skull than at others. Over the vertex it is loosely attached, except along the sutures. This shows how blood or pus may travel literally beneath the vertex. At the base, which is so irregular and perforated, the dura is either prolonged to the outer surface, becoming continuous with the pericranium, or its fibrous tissue blends with the areolar sheath of the nerves. Here it is so adherent to the bone that it would be difficult for blood or pus to collect in any quantity between it and the skull. Consequently, when the skull is broken we often have rupture of the dura, and this permits

easy escape of cerebro-spinal fluid. The connection between the dura and the skull increases with age, and in chronic inflammatory processes becomes very intimate; much less so, however, in acute.

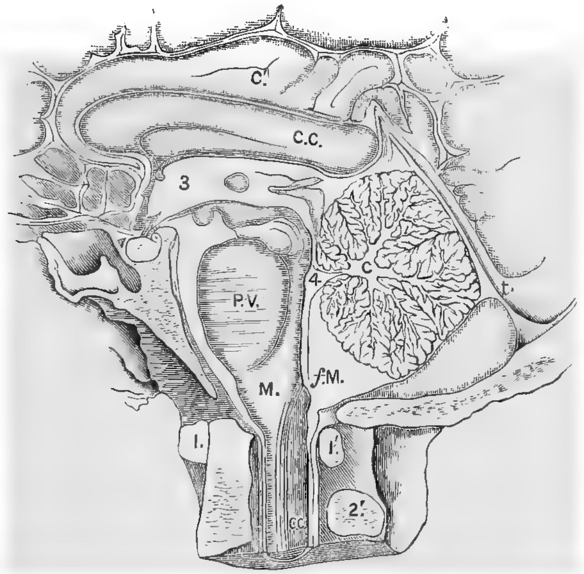
The potential interval between the dura and the arachnoid is termed the "*subdural space.*" In this space pachymeningitis hæmorrhagica occurs, and here considerable effusion may occur without marked symptoms, owing to its easy diffusion. Here, too, blood poured out from rupture of a vessel may find its way into the vicinity of the pons, cerebellum, and medulla, and even the lowest parts of the spine, and thus cause death by pressure upon remote points. Blood poured out here, even if it coagulate, is prone to shift its position and suddenly cause dangerous symptoms. In operations upon the brain it may do the same thing, and cause danger by pressure on the fourth ventricle. Macewen has suggested to obviate these risks by dividing operations in these regions into two stages—the first being devoted to loosening adhesion of membranes, thus obliterating the subdural and subarachnoid spaces. In intracranial irrigation great care must be observed in order to prevent accumulation of fluid in this space; for this reason the nozzle of the syringe should be carefully kept out of it. Macewen reports one instance where several ounces of fluid which should have escaped thus remained, its retention being followed by pressure-symptoms and some paralysis, both of which passed off in four days.

The *arachnoid* bridges over the convolutions and does not extend into the sulci. It contains few blood-vessels. Thus at certain points it is closely applied to the pia and cannot be separated; at other points it does not touch it. The *subarachnoid* space is formed in the latter way, and within this the greater part of the cerebro-spinal fluid is contained, a portion of it being found in the subdural space. The subarachnoid space is very unevenly distributed over the brain-surface; it is scarcely recognizable over the convexity, while over the posterior two-thirds of the base there is a wide interval between the arachnoid and the pia, extending in front over the medulla and pons and the interpeduncular recess as far forward as the optic nerves. Posteriorly, there is considerable interval between the cerebellum and the base of the medulla. Thus these important parts of the brain rest upon a water-bed (Fig. 411).

Between this space and the ventricles of the brain there is communication by the foramen of Magendie, extending into the lower part of the fourth ventricle through the expansion of the pia which serves to enclose it. Through the intermedium of this subarachnoid space there is also communication between the sheaths of the nerves and the cerebral ventricles. As the nerves escape from the brain and cord they are covered by all three membranes, the outer two being looser than the inner. Over most of them the arachnoid is only continued for a short distance, being lost in the perineurium. Along the optic nerves the layers remain distinct. Fluid injected into the subdural space may pass along the nerves as far as the limbs. It is important to realize this in order to appreciate how extensive a surface is exposed to inflammatory effusion in leptomeningitis—practically the whole cerebro-spinal system —and that there is continuity between the subarachnoid space, the perivascular canals of the brain, the lymph-spaces within the nerve-sheaths, and the ventricles of the brain. Although there is no direct communi-

cation between the subdural and the subarachnoid spaces, yet fluid can pass through the meshes of this membrane. From the subarachnoid space fluid can be injected into the Pacchionian bodies on the outer surface of the dura, which also project on the inner surface of the latter, some of them pressing into the longitudinal sinus. These may be cor-

Fig. 411.



Showing "water-bed" of the brain: 3, third ventricle; 4, fourth ventricle; *f. M.*, foramen of Magendie; *C. C.*, corpus callosum; *C.*, cerebellum (Macewen, from Key and Retzius).

rectly regarded as arachnoid villi, the interior of each of which is connected with the subarachnoid space, some holding that when pressure in this space is increased cerebro-spinal fluid may escape by means of these into the longitudinal sinus. Macewen suggests the possibility of the reversal of this process, so that fluid may pass from the sinus into the subarachnoid space when its pressure is diminished.

Closure of the foramen of Magendie may lead to internal hydrocephalus. If the skull or membranes be opened at the base, the water-bed is tapped and cerebro-spinal fluid escapes. This constitutes part of the danger in operating, as the relation of the parts in the skull is altered, and the medulla may rest upon bone to an extent sufficient to interfere with its function. A few hours of occlusion will, however, permit sufficient reaccumulation of fluid to prevent further ill effects. In certain cases of spina bifida the ventricles of the brain are also enlarged and communicate freely with the fluid in the thecal space. When, therefore, the tumor bursts, the fluid wells away from the brain, leaving the basal ganglia unsupported. A fatal issue may thus quickly happen. In certain forms of tubercular leptomeningitis there is great accumulation of this fluid in the subarachnoid space, and thus we get external hydrocephalus, or, if the cranium is too ossified to expand, its function becomes

lessened or arrested. The quantity of fluid escaping through fractures of the skull with rupture of membranes is sometimes very great. Bleeding from the nasal septum occasionally relieves cerebral congestion. Macewen suggests that the subarachnoid serum may be eliminated through the same channel.

The Pia.—This is the vascular coat of the brain. It is supplied with an extensive network of fine nerve-fibres derived from many sources, mainly the sympathetic and the cranial nerves, which accompany the vessels into the substance of the brain. The intimate relations of the pia and the brain, and the manner in which the blood-vessels dip into the brain-tissue, carrying with them their investment of pia, show that it is possible to have an isolated leptomeningitis, but that there must always be some accompanying encephalitis.

NERVE-SUPPLY OF THE CEREBRAL MEMBRANES.

The dura is supplied from the sympathetic, the fourth, the fifth, and the twelfth. The pia receives filaments from nearly all the nerves. Hence severe pressure on the membranes occasions widespread pain. Temporo-sphenoidal abscess will press upon all the branches of the fifth at the Gasserian ganglion, and also upon the third in its course.

INJURIES TO THE SOFT PARTS OF THE SKULL.

With the anatomical facts already stated in mind, and with two or three additional data concerning the cranial veins, we are ready to proceed at once to the consideration of external injuries. The venous anastomoses have so much to do with possible complications of injury that it must be emphasised here that the most significant of these are—

A. In the region of the occipital veins, which penetrate through the mastoid foramen and connect with the sigmoid sinus;

B. Along and through the sagittal suture, particularly its posterior extremity, where there are a number of small openings, sometimes abnormally enlarged, among which properly belong the parietal foramina permitting communication between the longitudinal sinus and the superficial veins; and

C. By means of the ophthalmic vein, which, according to Sesemann, empties its blood into both the cavernous sinus and the facial vein.

The frontal lymphatics conduct to the submaxillary nodes and those lying outside of the parotid. The posterior lymphatics empty into the lymph-nodes known as the "posterior cervical chain." The deep temporal lymphatics and those at the base of the skull connect with the retromaxillary lymph-nodes around the œsophagus.

PENETRATING AND INCISED WOUNDS.

To these the head is most exposed, and they may occur with or without loss of substance.[1] The galea, when divided or violently opened,

[1] It is of practical, and even of medico-legal, importance to emphasize the fact that *linear* wounds of the scalp may be produced by *blunt* instruments—*i. e.* ball clubs and the like.

causes more spreading of the wound than is seen elsewhere about the scalp. (Galea is a term applied to the aponeurosis of the occipito-frontalis muscle.) Prognosis of these injuries involving the soft parts alone is most favorable, providing only that they be properly cared for. Approximation and careful disinfection will nearly always lead to primary union, as surgeons have for ages noted. Only when removal of foreign material has not been complete, after checking of hemorrhage, have we anything to fear. Hemorrhage may be serious, even fatal. I have received a man into my hospital service almost at death's door from hemorrhage from a trifling wound in the scalp. The first care of such wounds, therefore, includes hæmostasis. When necessary, they may be enlarged and the source of bleeding looked for *in sitû*. Arteries can nearly always be isolated and tied. When, for any reason, this may seem impracticable, a snug suture will often check the bleeding. At other times acupressure or ligature *en masse* may be required. Antiseptic materials should, of course, be used. The most dangerous hemorrhages occur from the temporal vessels. During the American Civil War several times the temporal artery could not be secured, and ligature of the carotid was necessitated. Even injury of the occipital artery has called for carotid ligature.[1] Twice, at least, traumatic aneurysm has been observed after division of arteries of the scalp—once by Klaunig and once by Heine. Wound-areas should always be carefully shaved. This interferes with the use of hair itself for suture material, as has been sometimes recommended. There lurks too much danger about hair as a source of sepsis to warrant its use for this purpose. Of course, when these wounds are extensive the surgeon will put on a copious antiseptic dressing, will enforce rest in bed, apply ice to the head, regulate the diet, keep the alimentary canal open, etc.

Penetrating wounds form only short canals, and are seldom limited to the soft parts alone; the intruding body usually injures the periosteum and the bone as well. Not infrequently the presence of the foreign body itself or the injury of deep vessels complicates these wounds not a little. There is usually necessity for their enlargement and exploration, frequently for the removal of bone-splinters, particles of dirt, or foreign bodies. Such small articles as blades of penknives would frequently pass unnoticed in such injuries were it not for careful inspection and examination. Velpeau once saw a hemorrhage end disastrously after penetration of the temporal region. Sklifasowski has reported one arterio-venous aneurysm of the temporal region after venesection. Other similar observations were made by Bushe and Green,[2] and Des Ruelles has reported one case, and Bruns three cases, of traumatic aneurysm due to arteriotomy. These were all healed by compression.

One of the most interesting features about penetrating wounds of the supraorbital and adjacent regions, first based upon an observation of Dupuytren, is that of reflex blindness, explained by some as the result of injury to branches of the first division of the fifth nerve. All cases where only after a few days, or perhaps a few weeks, the amblyopia has developed have been, by various authors, ascribed to intracranial processes which were really excited at the time of the injury. Most of these instances have been explained as reflex processes, it being supposed that,

[1] *Jour. f. Chir. und Augenheilk.*, 1846, vol. v. p. 74.
[2] *Lancet*, 1827.

following the fracture or fissures produced by the penetrating wound, there were extravasations in the orbit which, as the blood extended along the cellular tissue between the inner and outer sheath of the optic nerve, pressed upon this trunk and so interfered with vision. In other cases it has been explained by injury to the globe itself. Under ophthalmoscopic examination there have been detected detachments of the retina and isolated ruptures of the choroid. In other cases little or nothing has been found to account for the disturbance, which has therefore been considered a functional paralysis without evident lesion. The first case which could be with definiteness ascribed to the first category was reported by Noyes.[1] The first case properly ascribed to the second category was reported by Nagel.[2] Fischer was perhaps the first to call attention to the pure reflex or functional forms.[3] At all events, every such case is well worth reporting, and requires careful investigation and study by itself before it can be properly classified.

Contusions and Similar Injuries.

We distinguish between the subcutaneous, the subaponeurotic, and the subperiosteal lesions and collections of blood according to the locality in which they most predominate. They are met with most often in the frontal and lateral regions. In mild cases the hemorrhage is most always subcutaneous, and the discoloration due to it may later spread over an extensive area. When the collection is large, and it is desired to prevent discoloration as much as possible, it can best be done by one or more incisions, the overlying skin being carefully cleansed, and by the turning out of the blood-clot. By this course considerable time may be saved. More important are the collections of blood underneath the galea. These may extend widely about the skull, and frequently amount to several ounces. They are softest in the middle and firmer about the periphery. They are often deceptive, in that around the margin is such a hard border as to make one think that the bone within these areas has been depressed. Much better would it be under these circumstances to incise and determine when in doubt than to run the risk of leaving depressed bone unelevated. When into this collection empty veins or arteries of some size, the tumor may increase in dimension for several days, so that the overlying skin is tightly stretched and circulation may even be cut off, while round about is œdematous tissue. When a large artery is torn through it is quite possible to have a pulsating hæmatoma, as, for instance, has been reported by Petit.[4] So distinct may these pulsations become as to be actually mistaken for brain-pulsations, which of course would lead to a much more serious view of the case than it would really deserve.

If such a tumor be found slowly increasing in size, it would be much better to freely divide it, search out the bleeding point, and stop all hemorrhage at once. When hemorrhage has subsided, however, the effused blood may be quite rapidly resorbed. Morel Lavallée saw an

[1] *Am. Med. Times*, March, 1862.
[2] *Berlin. klin. Woch.*, 1861, p. 61.
[3] *Archiv f. klin. Chir.*, vol. v. p. 33.
[4] *Traité des Maladies chirurgicales*, 1790, vol. i. p. 49.

enormous effusion of blood which extended over the entire frontal and temporal region, which fluctuated distinctly and discolored the overlying distended skin, entirely absorbed in two days, although the patient was at the same time suffering from a contusion, of which he later died.[1] It must be said that even after opening such a collection of blood the discovery of the divided vessel is not necessarily easy, and may be impossible; but at least the cavity can be packed for a few hours and the parts restored to their original condition in a short time.

The **treatment** of the ordinary injury of this kind to the scalp would consist in cold applications, perhaps with alcohol in the water, and compression by a suitably-arranged bandage. It is impossible to describe the necessary amount of pressure; it must be regulated to each individual case. A convenient way of making it is sometimes by the application of adhesive plaster to the smoothly-shaved skull, the strips being long enough to go completely around the head even twice. Still better, for a few hours at least, would be a rubber bandage. When necessary this may be fastened in place by adhesive plaster with the aid of pins. Outside of such protection ice-bags may be applied. Should absorption take place too slowly to suit the demands of the case, the bloody fluid may be withdrawn by an aspirator or, if firm, may be turned out after free incision.

Extravasations of blood underneath the pericranium occur for the most part in children and in very young individuals, in whom there is a relatively tender connection between the pericranium and the bone. These collections have been called by Hanner[2] "cephalhæmatoma of later years." Their outer appearance is scarcely distinguishable from that of the subaponeurotic variety. As a rule, however, they are softer, fluctuate more easily, and are surrounded with a quite unyielding margin. In most respects they are to be regarded and treated about as the preceding variety. They are to be explained in a measure by separation of the periosteum over the bone from which the venous emissaries pass, these being thus torn away at the time of the injury. If their calibre be enlarged, the collection of blood corresponds in size. Hecker[3] reported one case occurring in a soldier after a blow upon the forehead, in which there developed within twenty-four hours an enormous tumor which extended over the entire left side of the head. It was freely opened, its contents evacuated, and even then hemorrhage was not checked until further incisions were made upon the opposite side of the head. Septic trouble with local necrosis and eventual pyæmia resulted, of which the patient died. On examination there was found in the middle of the frontal bone an abnormal and very large emissary; the vein passing through it was torn abruptly across and was the source of the hemorrhage. (See the subject of Venous Blood-tumors of the Cranium.)

A peculiar result of contusions of the scalp is the formation of racemose angiomata or aneurysms by anastomosis, of which Heine collected 5 cases, and Bergmann has added at least 3 others. Several authors also have reported simple traumatic aneurysms of the scalp after contusions to the parts.

[1] *Arch. gén.*, 1863, vol. i. p. 191. [2] *Beiträge zur Pediatrik*, 1863, p. 40.
[3] *Erfahrungen und Abhandlungen a. d. Gebiete der Chirurgie*, Erlangen, 1845, p. 145.

CRUSHED AND LACERATED WOUNDS.

These are probably the most common of all, at least of those of serious type. The soft parts may be divided linearly, or extensive flaps may be separated from the underlying bone. The former injuries are produced by external objects which strike the head in a direction vertical to the surface involved. The more extensive injuries are produced by objects passing in an oblique direction. There is scarcely any limit to the extent to which injuries of this kind may be produced, nor to the recoveries which may follow from the same. These flaps may consist of scalp alone or of the underlying tissues down to the bone—and these may be separated in a corresponding manner—or the lines of injury may vary very much. It is possible to have a large flap of scalp and a small one of periosteum. Peculiar injuries are those produced by dragging upon the hair, as in scalping by machinery, etc. Under these circumstances a portion or the entire surface of the scalp may be torn loose, perhaps completely or perhaps laid up in one enormous flap. In other instances the cartilaginous ears are torn away at the same time, and even the cervical vertebræ exposed.[1] Twice it happened to Pirogoff to find the scalp torn off by means of the paws of infuriated beasts. Bergmann has reported a similar case, where the exposed bone became thickened in areas to a considerable extent.

The **course** and subsequent history of these extensive injuries depend very much both on the condition of the parts torn loose, or nearly so, and upon that of the margins of the surrounding tissue. The extent to which a primary reunion between separated tissues and the main structures is possible is in many instances astounding. Instances are on record where an entire scalp, having been torn nearly loose and reapplied at once, has healed in place, and to a lesser degree history has many times repeated itself in such cases.

In the **treatment** of these cases, again, the ordinary canons above laid down need simply to be rigorously carried out: first, hæmostasis; second, absolute surgical cleanliness; and, finally, perfect approximation of the parts, with opportunity for drainage and sufficient compression to hold parts gently in place. Of the untoward consequences of these injuries, the most common perhaps is diffuse phlegmon or septic inflammation of the type of outspoken erysipelas or of a low-grade cellulitis, with infiltration and multiple collection of pus in the neighborhood. It is particularly important to remember that the paraosteal connective tissue underneath the galea connects directly with the periosteum, and that a septic process once begun in this tissue may have no definite limits. For this reason, therefore, it is well not only to be strictly aseptic, but to permit opportunity for the escape of retained fluids. When periosteum is torn loose in a distinct flap by itself and its viability is doubtful, it is probably better to remove it than to endeavor to sew it in place and have union fail in consequence. We have learned that the pericranium is by no means necessary, and that the soft parts external to it will unite directly to the bone when it is lacking. Better, then, than contused and doubtful fibrous tissue of this kind is it to have it completely out of the way. It will be readily understood that the

[1] For references see Bergmann, *l. c.*, p. 43.

great danger in these cases of septic disturbance concerns not so much what goes on outside of the bone in parts accessible, but what extension may occur through the emissaries into the sinuses and membranes beneath, with consequent production of septic thrombosis, meningitis, etc. Better also is it always to cut away with free hand so much of the border of the scalp or of any underlying tissue as is irregularly shaped or has dirt ground into it. Such tissue can never heal *per primam*, and is a constant source of offence, whereas a neatly-trimmed wound immediately invites to speedy union. The scissors, therefore, is a very essential instrument in the treatment of these injuries.

More than a century ago Petit and Pott gave the advice to make lateral incisions in the bases of extensive scalp-flaps, and even to-day this advice is in many instances good. Often it will be wise to introduce small drains through these incisions, which drains may be made of horsehair, catgut, gauze, or even tubes. The ligatures may be of horsehair, catgut, or silk, according to the fancy of the operator. The tendency of large flaps to roll up on the skull and to shrink up toward their bases was early illustrated by Hilton.[1]

There is another reason besides those given above for early and complete union of these wounds—as complete, at least, as the circumstances will permit. There is nothing which so protects the exposed bone from superficial necrosis as to have it immediately covered with its natural roofing of soft parts.

It has long been known that after many of these injuries to the scalp patients will suffer from neuralgias apparently of traumatic origin. These seem for the most part to be due to the entanglement of nerve-fibres within the cicatrices as they form and contract. In other instances the pain complained of is severe and disabling. When it can be located the involved area may be dissected out; when not, it may be necessary to treat the affected nerve-trunk in its course. Instances are on record where lesions thus produced have given rise to epilepsy and epileptic disturbances. The frontal region seems more likely to be involved in this way than the occipital. Echeverria[2] has reported at least one case of complete recovery after stretching of the supraorbital nerve without excision. In 1874, Koeppe[3] alluded to the well-known psychoses which may follow the reception of injury and the formation of sensitive places upon the scalp, and of the relief which follows extirpation of the same. The neurologists have paid considerable attention to this matter since that time, and it is now a very well-established procedure in all neurotic disturbances where the lesion seems to proceed from a painful cicatrix in the scalp, to make an absolutely complete extirpation of the same, either a formal operation by itself, or to combine it with such other operative procedures as may seem necessary.

Injuries to the Bones of the Skull.

INCISED WOUNDS OF THE SKULL.

The cleanness of an incised wound depends in a large measure upon the sharpness of the instrument which inflicted it. The smoother this

[1] *Med. Times*, 1861, i. 226. [2] *Archives gén. de méd.*, 1878, Decembre.
[3] *Deutsches Archiv f. klin. Med.*, 1874, p. 353.

be, the smoother will be the borders of the bony lesion, and *vice versâ;* and the more massive the object which may have penetrated into the bone, the more will it separate and splinter the skull itself. On the weapon, then, or the object which inflicts the injury, will depend the nature of the wound in the bone and the complexity of the bony fissure. It may also be said that the participation of the brain depends in a large measure upon the same conditions. Sharp weapons will penetrate more deeply than dull or large ones.

According to the depth of the lesion we may distinguish between penetrating and non-penetrating injuries to the bone, the latter including all injuries to the outer table and to the diploë. In fact, we may speak of—

1. Simple superficial cuts and injuries confined to the outer table;
2. Division of both tables by means of a cut received more or less vertically to the bone-surface;
3. Oblique or horizontal cuts which remove both tables, or which at least open through them both;
4. Complete separation of a segment of the skull, so that the bony fragment is connected only by a hinge of soft parts.

The first of the above constitute the so-called "linear wounds" and other varieties of flap wounds, or those with loss of substance. The more severe injuries are connected not merely with the splintering or with the removal of fragments of the bone, but are made more serious by more or less depression of the surrounding margins, by the complete extrusion of pieces of various size, or by the coincidence of more or less extensive fissures extending for some distance. This is true, for instance, of wounds like those made by a hatchet; indeed, the extensive splintering produced by such weapons is so universal that it may play a rôle in medico-legal medicine.

A large proportion of linear as well as of flap injuries are connected in a more or less typical way with fissures, either from one or both angles of the wound, that lead off a crack in the bone, usually in the direction of one of the meridians of the skull, and often to a considerable distance. Should this take the direction of the coronal suture, the fissure may extend to the base, while in injuries to the frontal bone in a sagittal direction there is often a continuation of the split into the orbit itself.

It must necessarily result, from what has been above stated, that the principal significance of these injuries to the head consists in the extent to which the brain or its membranes are injured. Simple penetration, whether it be sharp and smooth or crushed and lacerated, involves in itself the question of danger. In either case it may lead to irritation and inflammation in the sensitive arachnoid. Experience shows that even deep penetrations into the hemisphere, so long as the ventricle is not perforated, are quickly recovered from, often even without material disturbance. An instantaneous incision, even though the skull be deeply penetrated and the bone cut into, may be received without particular disturbance of function. But every such injury, as well as every exposure of the dura, may be the open path by which infection is invited and by which a fatal inflammatory result is quickly brought about; in other words, it is meningitis which offers the greatest danger after all these

injuries. Quesnay in his celebrated memoir alludes to twenty-two soldiers whose skulls were more or less cut away by blows of the sabre; all of these died finally, although in the beginning there were no serious symptoms of septic disturbance. So in 13 cases noted in our *Medical and Surgical History of the War*, 9 died of meningitis, 2 of brain-abscess, 1 of pyæmia, and 1 of tetanus. Hemorrhages from the cranial cavity after penetrating wounds are not only easier to recognize, but are much more accessible, than hemorrhages following fractures. Oftenest the superior longitudinal sinus is injured.

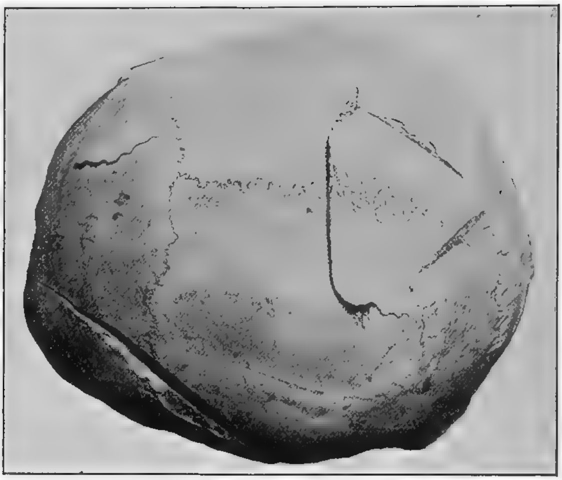
The non-penetrating injuries of this character have for the most part a favorable prognosis. Thomson saw in the British hospitals after Waterloo thirteen sabre and other wounds of the skull in which the external tables alone were involved; although in each instance some portion of the bone exfoliated, all recovered without intracranial inflammation.

Concerning the changes in the bone after recovery from these injuries, one may find a number of museum specimens which are instructive, of these none more so than the specimens in our own Army Museum. They illustrate the repair after injury and the pathological processes occurring in the bone which permit of recovery. Sometimes there is only membranous closure; at other times true bone fills up the defect; and not infrequently osteophytes form externally or internally, or both. When bone-flaps are raised they may reunite without much alteration, or their contour or arrangement may be more or less altered, with change in level. As a rule, a bone-flap which has been nearly or completely severed undergoes subsequent necrosis, and this fact offers strong reason for removing it at the time of the first dressing. Penetration of the cranial cavity may be recognized often by the discovery of pulsation in the parts presenting at the wound without further examination: the blood or coagulum and the cerebro-spinal fluid which fill the defect usually will show distinct pulsatory oscillation. Such a discovery will always justify not merely the most painstaking care, but frequently further operative exposure, in order to meet any further indication.

In general, with regard to **treatment** of these injuries it is so slightly different from that of compound fractures of the skull as to scarcely call for distinctive mention. The writer recalls the case of a man who fell against a circular saw in rapid motion, which made a long cut into the skull parallel to the middle line, at a little distance from it. The exact depth of the wound into the brain was never learned; hemorrhage was very free, but ceased spontaneously. This occurred in the country, and during two or three days the medical men in attendance disputed so actively over the proper treatment that the patient was finally found to be out of danger before the question of treatment had been satisfactorily settled by the attendants: the man practically recovered with no care at all. The cases which permit of most doubt are those where a question may arise as to the splintering or depression of the internal table; and when in this respect there is doubt it will be perfectly justifiable to cut away bone, either with forceps or a trephine, exposing a sufficient area of dura to permit the final settlement of all doubt. Should there be injury to one of the large sinuses, it may either be tamponed and the wound dressed in an open fashion, or the sinus may be doubly ligated, and, with all possibility of hemorrhage thus prevented,

the wound may be closed and drained if the operator see fit. Hemorrhages from the middle meningeal artery call for the same treatment as under any other circumstances. With regard to loosely-hanging fragments of bone, if asepsis can be maintained their vitality is merely a

FIG. 412.



Skull showing nine sabre-cuts (U. S. A. Museum, No. 970).

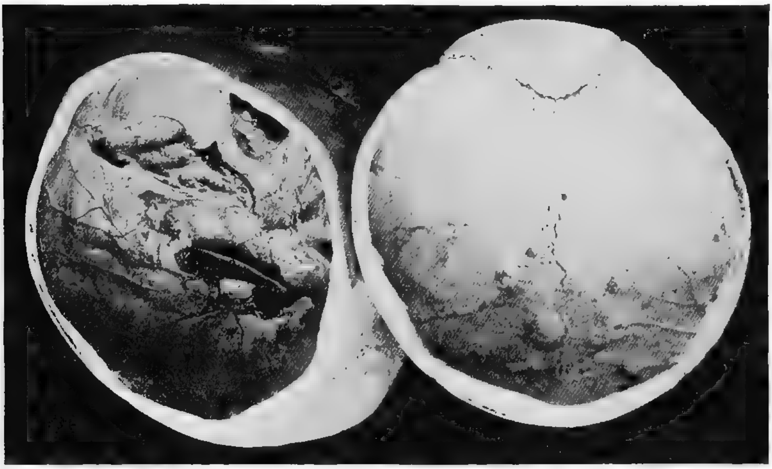
question of vascular connection. Should this be considered sufficient for their nourishment, they may be left; otherwise it would be much better to remove them and unite the soft parts as usual. Should it be a difficult question to decide, the effort may be made, taking the precaution to introduce secondary sutures, which may be tied in a bow-knot, and to pack in gauze between the wound-surfaces of the scalp in such a way as to prevent their primary union and yet stimulate granulation, with a view to removing the same a few days later and then deciding upon the fate of the bone-fragment. If it be pale and non-vascular, it may then be removed, and the granulating surfaces about it reclosed by means of the secondary sutures. On the other hand, if viable and living, one needs only to remove from it the gauze and close the wound. In all these injuries, however, when possible, primary union should be sought and striven for. Finally, should there be necrosis of the overlying soft parts, early or late a plastic operation may be called for. It is much better to do this at the time, however, after having cut away all those parts which are so bruised or have so much dirt ground into them that they are sources of offence. If these be smoothly trimmed away at the time of the first wound-dressing, and whatever plastic rearrangement may be necessary be made, there will be little possibility of disturbance in ideal wound-healing.

PENETRATING WOUNDS OF THE SKULL.

Sharp objects, such as knife-blades, bayonets, arrow-heads, and many other weapons, penetrate to various depths within the cranial cavity—

may even, indeed, completely perforate it and appear through a counter-opening. When the direction of penetration is perpendicular to the surface, there is very likely to be more or less depression, at least of the

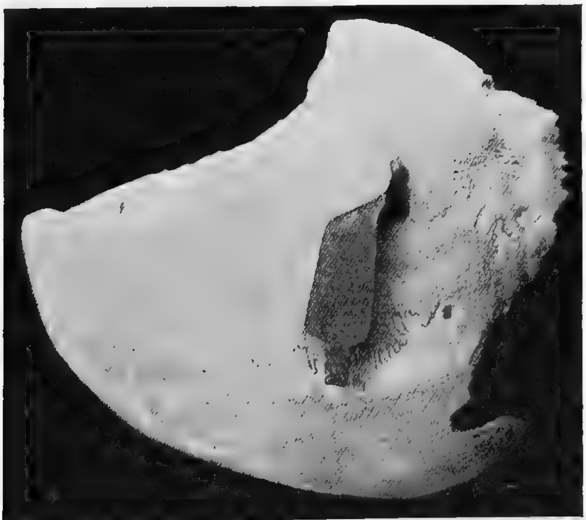
FIG. 413.



Perforating arrow-wound of skull: arrow *in sitû* (U. S. Army Museum, No. 6677).

inner, if not of the outer, table. If it pursue, on the other hand, a very oblique course, the bone-injury may be confined largely to disturbance

FIG. 414.



Arrow-wound of skull (U. S. A. Museum, No. 5907).

of the external table. Upon the direction, then, as well as upon the force of penetration, will the anatomical lesions depend. These injuries are of peculiar danger, because of the immediate injury to the brain and

the invitation thereby given to infectious processes in the membranes and the brain itself. This is frequently increased by the entrance and lodgement of foreign bodies. A peculiarity to be noted with regard to many of these injuries inflicted by small weapons—for instance, knife-blades—is the tendency to separation of a small fragment of the inner table and its arrangement perpendicularly to its previous position, so that we have a small scale of bone at right angles to the surface of the skull, pressing its sharp edge in upon the dura. This has been noted by Rokitansky and Stromeyer, among others. If this be not appreciated early in the case, it may be known by the appearance of small scales of bone which escape with pus should the patient live long enough to develop the common result of abscess.

The course of a case of penetrating wound of this character is favorable mainly in proportion as serious disturbances of the cranial contents are avoided. Experience has accumulated many cases in which small objects, even so large as bullets, have inflicted penetrating wounds, have lodged, and have remained often for years and until death from other causes, without giving rise to disturbance. For instance, Hergt[1] saw a

Fig. 415.

Bullet lodged in ethmoid after passing through orbit; patient lived two years (U.S.A. Museum No. 1108).

penetrating wound an inch away from the external ear quickly heal; after a year and a half the scar began to be elevated, and soon there became visible the sharp iron point of a knife-blade, which when withdrawn had a length of a little over an inch. Pagenstecher[2] relates the history of a woman of twenty-four who in her seventh year ran a knitting-needle through the right eye into the roof of the orbit. Fourteen years later brain-symptoms were still lacking, although on account of danger of sympathetic trouble in the other eye the injured globe was removed, at which time a piece of the needle was discovered and extracted. Meningeal inflammation followed, but subsided, and nine weeks later she was discharged; within a month again she became sick

[1] *Heidelberger med. Annalen*, 1835, i. 461.
[2] *Klin. Monatsblatt. f. Augenheilk.*, 1864, p. 166.

and died. The autopsy revealed basilar meningitis. T. H. Simon made an autopsy on a patient, dying of tuberculosis, on the outer border of whose frontal bone there was found a round opening which led inside of the skull; this was completely filled by a rusty nail, which could not be withdrawn on ordinary effort. No bony changes were noted around this opening, no history accounted for the presence of the nail, the man's wife being totally ignorant of his ever having received any injury. Numerous other instances of this same general character could be adduced to show the toleration with which the brain occasionally bears the presence of a foreign body. There is some reason to think that in such injuries as those reported above the rigidity with which the foreign body is retained by the bone is of itself a protection against meningeal infection; at all events, cases of fatal meningitis after such injuries as these are rare, and in the majority of cases proving fatal it has been brain-abscess rather than meningitis which has caused death. A celebrated case of this kind occurred in Dupuytren's service. In this a brain-abscess was produced by a foreign body which had long since penetrated the brain. Dupuytren trephined, drew the foreign body out, incised the dura, sank his bistoury into the brain, and evacuated a large collection of pus; the patient did not recover.

The **signs and symptoms** of brain-abscess in these cases are not always classical, but will depend much upon the part of the brain involved. If in the motor area, they will give rise usually to localizing symptoms; in other places the history of injury, the presence of scar, and the existence of general brain-symptoms are sufficient to justify exploration on suspicion of abscess. Even in non-penetrating wounds the fixation of broken knife-points or similar objects may give rise to tedious disturbances, including usually the phenomena of caries or necrosis of the surrounding bone. In at least one instance the encapsulation of the point of a knife-blade in the external table has been met with. This was in the hospital in Wiesbaden, where upon the examination of the body of an old man who had been injured during his early years the point of a knife-blade was found, underneath a scar, within the external table.[1]

It is therefore evident that in all but exceptional instances the withdrawal of a foreign body is indicated; and, though this is not always easy, it should more than justify—should indicate—the performance of whatever operation may be necessary for its release. Should, therefore, the examination of the weapon or the body with which the injury was inflicted indicate that its extremity was lost, and should the appearance of the parts justify the suspicion of its presence within, it would be good surgery to explore, cutting away enough bone to permit of absolute satisfaction with reference to this point. Bardeleben has suggested that for the removal of some of these objects the ordinary needle-holders serve a useful purpose. The more quickly the case is seen after injury, the more uneventful will be its subsequent course and the easier the performance of whatever is called for. Bardeleben has related the following case:[2] A soldier received a penetrating wound of the left temporal region, which had been superficially sewed up. Not long after he

[1] *Vide*, also, Bergmann, *l. c.*, pp. 75–79.
[2] *Deutsche Zeitschft. für Chir.*, 1872, p. 311.

was seized with severe headache, the wound reopened and discharged pus; then followed paralysis of the right arm and leg. Bardeleben discovered a fifteen-millimetre-long knife-point projecting within the skull, and removed it; recovery followed and the paralysis disappeared. When the penetrating wound is surrounded by visible or palpable splinters of bone, it comes under the category of those compound fractures which call urgently for trephining or similar radical operation, and is to be so treated.

CONTUSION OF THE CRANIAL BONES.

Under the term "contusion of the bones of the skull and of the dura mater" Percival Pott, about a hundred years ago, described a clinical picture which has ever since passed under the term which he gave to it, and for which his description has been considered sufficient and classical. The symptoms consist practically of the following: There is, first of all, a recognizable solution of continuity of the bone, either with or without injury to the overlying skin, soon after whose occurrence there develop certain characteristic symptoms with pain at the injured spot. This pain gradually extends over the entire head; there are sensory and mental disturbances, along with tendency to nausea and vomiting, vertigo, a quick and firm pulse, with disturbed sleep. Soon after the injured part begins to swell, the tumor, however, becoming neither particularly large nor very painful. If now this be opened, one finds the pericranium separated from the bone by a dark semi-fluid mass and the surface of the bone rough and discolored. The subsequent symptoms succeed each other rather quickly: the skin becomes warmer; the pulse quicker and firmer; the anxiety and restlessness increase; chills and pyrexia occur; the patient loses strength; and, finally, convulsive motions, sometimes with delirium, sometimes with paralyses or disturbances of special senses, follow. According to Pott, the actual reason for all this disturbance is the peculiar affection of the dura which follows the injury. As the pericranium is loosened and separates from the outer surface of the bone and the tumor develops, so the dura is affected on the inside of the bone, since between it and the bone pus collects, or at least that which breaks down into pus.

The early recognition of this more or less typical course is of great importance, because of the necessity for early operation; that is, the opening of the bone by means of the trephine and the evacuation of the material collected beneath it. In other words, a diagnosis of this kind is an indication for trephining. With this in view, the mere disturbance of the soft parts outside the bone is of very minor importance as compared with the recognition of the intracranial condition. It must be said, however, that the frightful results which Pott ascribes to simple contusion of the bone were due much rather to the subsequent meningitic or encephalitic, even pyæmic, processes which were the result of infection brought about at the time.

It does not follow that there is any serious amount of crushing of the bone as the result of many injuries to the skull: a wounded bone may proceed readily and immediately to repair by granulation without showing any of the disturbances described by Pott. On the other hand,

in some cases there is necrosis of the margin of the bone-wound, either on account of mechanical injury or because of subsequent infectious or phlegmonous processes incited in the bone by infection of the wound. It is most fortunate when a small sequestrum separates as the result of immediate formation of granulations, even though this process be tedious. Under these circumstances the limit to the necrotic action may be very narrow and confined to the external table, or this may extend over an area several centimetres square. In serious cases, however, where there is extensive infection of bone, necrosis may lead to an osteomyelitis by continuity and the development of thrombi with their almost inevitable consequences. Injuries of the bone by themselves consist for the most part of ecchymoses just outside or inside of the skull, and hemorrhages into the spongy tissue of the bone itself. One has frequent occasion to see the anatomical disturbances in freshly-injured bone in cases of rapidly-fatal fracture of the skull. When one saws across the bone or opens it with the chisel, its cavernous structure is found infiltrated with blood to the fullest extent possible. The fact that so many skull-fractures terminate favorably is simply another expression of the fact that by no means all contusions of bone are necessarily followed by serious symptoms; in fact, most of them go on with but little disturbance; the effused blood, either on or inside of the bone, is quickly absorbed and disappears, and the original condition of the parts is gradually restored. Naturally, the more freely these parts are exposed to the possibility of atmospheric infection and remain without protection therefrom, the greater the danger of putrefaction and infection: it is not the traumatic irritation, but that due to sepsis, which causes frequent fatal results. Particularly is this true of exposed diploëtic structure, in which infectious processes travel rapidly and easily, as is well known. Contusions of the skull in which the skin is preserved without serious injury are followed by only circumscribed disturbance; they may be followed by simple hyperplasia of the periosteum, which will be recognized by the nodular thickenings met with on the outside of the bone. Even these may vanish more or less speedily, or they may be replaced by exostoses, or at least by ossifying substitutions for the original fibrous tissue. In the larger proportion of cases, however, with external injury there will remain an obstinate ulceration with more or less caries and possible necrosis. These may be so resistant as to call for operative removal of the diseased bone.

General Remarks concerning Fractures of the Skull.

For purposes of general convenience we divide fractures of the skull into those of the vertex, those of the lateral region, and those of the base, following for this purpose the regional anatomy of which so many descriptions may be found in the books. The vertex is exposed with very little protection between its surface and the bone; the lateral region, however, has more or less muscular and other armor, and in front is largely protected by the bones and tissues of the face. The base of the skull is made almost inaccessible to operation by its location, although it frequently suffers indirectly as the result of violence. Its diploë is much reduced in amount, and, while perforated for many open-

ings, it is reinforced by the peculiar architecture of the skull. A certain proportion of skull-fractures are confined to the vertex; certain others extend from there toward the base; while a third variety, numerically the smallest, concerns the base alone. The proportion of skull-fractures to those of the skeleton in general varies from $1\frac{1}{2}$ to, perhaps, 3 per cent. depending on the character of the institution from which statistics are secured. Fractures of the vertex are nearly three times as frequent as those of the base. They are for the most part inflicted by actual violence, and usually first involve, and then radiate from, that point at which this violence has been inflicted. So-called "direct fractures" are limited for the most part to the neighborhood of the injury. On the other hand, we have indirect or radiating fractures, which extend to considerable distances. Fractures of the skull are produced in two ways: first, by the direct application of violence, as from weapons, blows, bullets, etc.; and secondly, by injuries where the patient falling strikes his head against some object and suffers either at the point of impact, or else from the weight of the rest of the body as it is impinged against the base of the skull. They may vary from the slightest fissure, which is followed by practically no symptoms, up to the most complicated and crushing injury, in which the skull is shattered into many fragments. They are described as being of the following forms:

1. Fissures.—As the name implies, these are practically cracks in the skull, as they may be seen in glass or crockery-ware, and are not necessarily followed by the slightest displacement. Nor do they necessarily involve the entire thickness of the skull. For instance, Hofmann[1] has described a skull with three crossing fissures of the lateral region produced by a blow upon the side of the head, only one of which extended clear through the skull, the others being limited to the external table. In the majority of cases, however, the internal table is likewise fissured, although the lines of fissure of the two tables by no means necessarily correspond. Gosselin[2] has described a skull in which he met with fissures of the external and of the internal table of the parietal bone, these fissures crossing each other nearly at right angles. The term "linear fracture" has also been applied to these cases, the condition being anatomically practically the same, the understanding being in either case that the margins of the break are inflexible and their levels unaltered; else they are spoken of as fractures with depression. We frequently find fissures, simple or forked, whose branches widely separate from each other and enclose perhaps considerable areas of the skull. These may be straight or very irregular in their course, limited to one bone or extending over two or more. Fissured fractures also frequently radiate from areas in which more serious injury has been inflicted. In this way it may happen that a fissure or crack may extend almost entirely around the skull. An extreme case of this kind was that of the unfortunate duke of Orleans. So Hester described[3] the skull of a young woman which was literally divided into halves by a fissure extending from the foramen magnum up in a median direction clear across the occipital, parietal, and frontal bones into the ethmoid and

[1] *Gerichtlicher Medicin*, 1878, p. 462.
[2] Quoted by Félizet, p. 20.
[3] *British Med. Journ.* for 1868.

sphenoid. So, too, Chandler is reported by Astley Cooper to have met with a case in which the skull was practically broken into an anterior and a posterior half by a fissure extending at right angles to the antero-posterior axis. Numerous other instances of this kind are on record. I have met with one case in which the cranium was practically broken loose from the face. In almost all these fractures the two margins are on the same level. Nevertheless, in one preparation in the Museum of St. George's Hospital one side of a long-fissured fracture is depressed beneath the opposite margin. When depression occurs along with minor fissure, it is usually in young patients with still flexible skulls.[1]

2. Splintered and Comminuted Fractures.—In these there is usually a sort of border-line within which the bone is more or less broken into fragments, and beyond which nothing extends save possible fissure. Within this area there are frequently numerous fragments of various size, with considerable depression; the particles are often loosened from one another, and may be easily picked out with forceps, while at other times they are driven together irregularly, and, as it were, dovetailed. The explanation of the relative infrequency of injury at a distance in these instances is that the violence has been practically expended at the point of impact. Sometimes from the exact point of impact the lines of fracture radiate in such a way as to entitle them to be called "stellate fractures." The number of fragments which may be found and removed from these cases frequently exceeds twenty-five.

In comminuted fractures we distinguish those with and without de-

Fig. 416.

Cranium of a negro, fractured by butting (U. S. A. Museum, No. 6900).

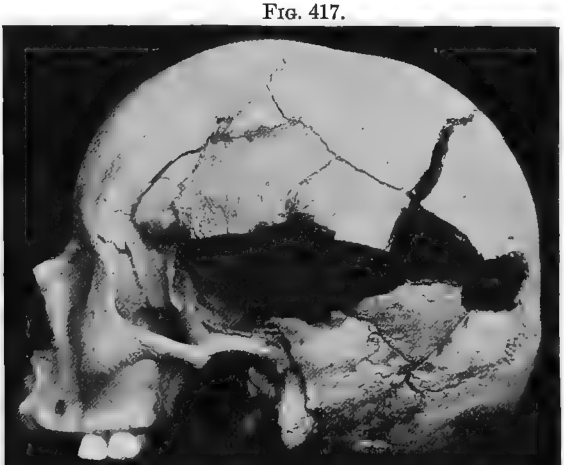
pression, the latter being of course much the more severe. The depression may be central or peripheral, the gravity of these cases depending

[1] *Vide* also Klemm, "Zur Casuistik der complicirten Schädelbrüche," *Deutsche Zeitschft. f. Chirurgie,* xxxvi. p. 110.

very much on the extent of depression of the depressed area and on the penetration into the brain of fragments, these of course varying according to the extent and character of the violence by which they are inflicted.

3. Fractures with Absolute Loss of Substance.—The simplest of these are those produced by penetration of bullets, by which a round defect is produced in the bone, frequently with extensive splintering and loss of substance by penetration of fragments into the brain. (The matter of gunshot fractures of the skull is dealt with separately, and consequently will receive but little attention in this place.) The opening of the inner table under these circumstances is frequently larger than that of the external, and is surrounded by a margin of splintered and more or less depressed fragments. This may be equally the case in perforation by other objects than bullets. When a bullet goes completely through the skull, it carries in a larger area of inner table and carries out a larger area of external table; in fact, so extensive and widespread is frequently the result of injuries of this kind that the skull has more the appearance of having been broken by some bursting force from within than by anything applied from without.

Fig. 417.

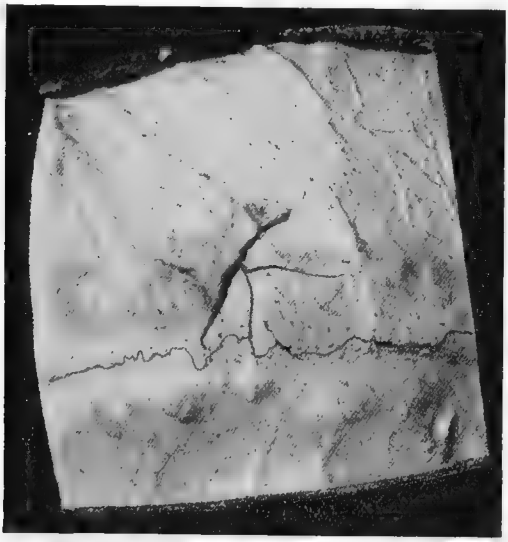


Multiple fracture of skull from sabre-cuts (U. S. A. Museum, No. 1318).

It is quite possible to have fracture of one table without that of the other. This is most often true of the external table, but it is a well-established fact that it is possible to have isolated fractures of the vitreous without perceptible injury to the external. These, however, are unusual, and are rather surgical curiosities than frequent results. Fissures of the internal table are sometimes longer than those of the external. In the Freiburg Museum is a skull with a long lateral fissure of the frontal and lateral region, confined entirely to the inner table, while another near by extends through both. In gunshot wounds with radiating fractures the number of these in the internal table usually exceeds those of the external. So, too, when there is depression from external injury, the inner table is usually broken into more fragments than the external.

In isolated fractures of the inner table it is usually broken into several more or less loosened fragments, with more or less injury to the underlying dura; much more rarely is it simple and uncomplicated.

FIG. 418.

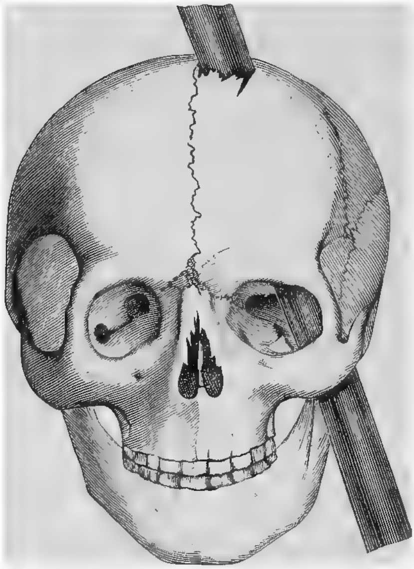


Fracture of inner table *only* (U. S. A. Museum, No. 1560).

One of Bergmann's illustrations shows the skull of a Papal soldier wounded in 1848, dying of meningitis fifteen days after injury. Externally there were two trifling fissures; internally the inner table was found broken into four fragments, somewhat displaced and driven in in a conical shape.) (Numerous references to literature in Bergmann, *l. c.*, p. 109.)

Solutions of continuity of the external tables alone have been well known ever since they were classically described by Astley Cooper. They were frequently found in patients dying of meningitis or pyæmia after injuries to the head. There is reason to suspect these injuries in many cases where opportunity for examination is not afforded—in other words, where recovery has ensued. Consequently, the diagnosis in many instances is conjectural. Still, there are certain cases where a slight depression may be explained in this way, and where the absence of serious symptoms indicates that the trouble is confined to the outer surface of the bone alone. If, however, the depression, real or imaginary, be larger than a silver twenty-five-cent piece, or if it be abruptly circumscribed and perceptible throughout the circumference of the circle, it is so probable that the internal table is injured that it will always be wise to explore and probably trephine. Many years ago Demme laid down the rule that a furrow may be ploughed in the external table by a ball which strikes the skull tangentially, without serious or any injury to the inner table. This, however, is not true of the missiles used in modern warfare, and it would be a very unsafe principle to hold to. The only exception to this statement would be in those localities where the diploë

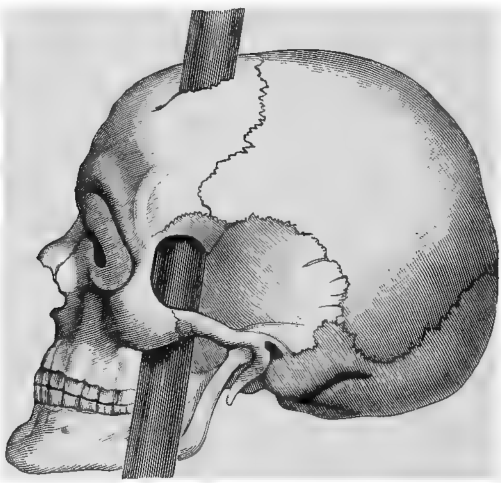
Fig. 419.



Harvard "tamping-iron case."

is met with in considerable extent, as, for instance, the mastoid processes, the frontal sinuses, etc. In the Army Museum in Washington there is

Fig. 420.



Harvard "tamping-iron case."

no preparation showing gunshot injury to the external table alone, with the exception of the regions of the frontal sinus and the mastoid process. By the explosion of bombs injuries are sometimes met with in the external table alone. Demme[1] reports concerning some of these where the

[1] Demme, *Militarchirurg. Studien*, 1863.

sharp oblique fragments of the bombs have produced injuries of this character. So also after explosion of blasts the same results have been produced. There are also a few instances on record of depression of the firm external table into the mastoid cells after injuries of similar character.

The celebrated Harvard "tamping-iron case" has been so often described that it would seem unnecessary to detail it here. Let it suffice to remind the reader of its remarkable character by a reference to the illustrations (Figs. 419, 420).

MECHANISM OF FRACTURES OF THE VERTEX.

Two factors play the essential rôle in producing fractures of the vertex—namely, the shape and extent of the surface involved and the violence of the impact. A further factor of varying importance, which never permits of exact estimate, is the natural elasticity of the skull. The skulls even of the oldest individuals are somewhat elastic, and those of young people present sometimes a surprising amount of this mechanical peculiarity. Fracture, then, only happens when the natural limits of this elasticity have been passed and the cohesion of the bone has been overcome. Children often suffer from very marked depression or inbending of the vertex without actual fracture. Green, for instance (quoted by Erichsen, vol. i. p. 318), has reported the skull of a child so deeply depressed by injury that an egg might be laid in the pit thus formed; this child did not display any brain-disturbance and remained well. On the other hand, skulls are often abnormally fragile, and Foville[1] has emphasized that among the insane the cranial bones are often so porous that they can be very easily pressed out of shape or otherwise injured. Obviously, most solutions of continuity, and particularly most depressions, are brought about by objects which have a small impinging surface. Much may be learned from studying fracture in inanimate objects. When one tries to break a stick, for instance, the parting of fragments begins always on the convex, stretched side, and not upon the concave and compressed side. Rauber made many experiments to determine the resistance and firmness of bone-tissue; so, too, Teevan, who sought to experiment by blows and other injuries with blunt-pointed objects against the convex surface of the skull, and whose illustrative preparations are to be found in Guy's Hospital Museum. The results of injuries of this kind are well illustrated in a specimen described by Thiersch, and another by Bergmann. The latter was the skull of a suicide who fired into his own mouth a bullet which penetrated the hard palate and the body of the sphenoid and lodged in the parietal bone. The internal plate was not fissured, while the external table was; over these fissures and beneath the scalp there was a collection of blood. This will account, when the conditions are reversed, for injury to the inner table in many instances where the blow has first depressed the external. Teevan's experiments[2] well showed that any missile which impinges upon a limited area of skull without too great violence—such as a stone or a stick—can produce fractures of corresponding character

[1] *Dict. de Méd. et de Chir.*, Paris, 1829, vol. i. p. 551.
[2] *Med.-Chir. Review*, 1865, 36, 129, and *Trans. Path. Soc.*, 1865, xvi. 217.

in the internal table. It is not necessary that a bullet should strike obliquely, but only that its violence of impact be somewhat mitigated.

The resistance of the skull is in a measure separable from that of the bony substance of which it is formed and from the peculiar shape which it may possess. In injuries of limited extent it is enough that the skull-wall is composed of somewhat elastic substance; for those of greater extent the skull is to be considered rather as a globe possessed of a high degree of elasticity, as the result of which its shape will give or alter more or less before a genuine fracture results. One must have this elasticity of the skull demonstrated in some practical way before he fully appreciates what it means. For instance, Bruns fastened an uninjured head between two planks with a vise, and then by varying degrees of pressure studied to what extent he could alter its shape. It was easy to see that upon compression in one diameter increase of the other diameter resulted, and that the skull could be more or less compressed in certain directions without fracture resulting. In one instance it was possible after pressure laterally and elongation of the greater diameter to reverse the pressure and restore it to its original dimensions. The degree of elasticity of different skulls is highly variable: on the average, the adult skull can be reduced in its lateral diameter by fifteen millimetres before it breaks, while the skull of a twelve-year-old boy suffered from fracture at the base when this diameter was reduced even by five millimetres. It must be acknowledged, however, that the conditions are very different when this compression is brought about slowly, as in these experiments, or instantaneously, as when the result of accidental violence.

There are other ways, however, of estimating elasticity under the latter conditions: one is by suspending skulls and swinging them, as in certain physical experiments, judging by the index of an arbitrary scale; or one may do as Félizet[1] did, by filling skulls with paraffin and dropping them from definite heights, varying from three to one hundred and fifty centimetres. At the height of one metre it was found that the skull would break, but would rebound to its original form in spite of the fracture. All these experiments naturally have only an approximative value, and yet are all extremely suggestive and shed much light on the occurrence of injury to the living. Rauber, for instance, could very easily demonstrate that the elasticity of a fresh, warm head with circulating blood is somewhat less than that of the dried skull.

The result of force applied over an extensive surface is much the same as in the above-mentioned experiments. The alteration of form is not limited to the area of impact, but the entire skull is, at least momentarily, altered in shape. From injury to the top of the head, whether by falling objects or by a falling individual, the perpendicular diameter of the skull is decreased, while the longitudinal and lateral diameters are increased.

In all instances where a skull bursts the line of fracture resulting therefrom opens at least for the instant, although it may completely close again. This is shown by the fact that hairs are often found included within closed fissures. Such a condition has been pictured by Koenig, who has found them in the dried skull. Schlemmer[2] describes three

[1] *Recherches anat. et exper. sur les Fractures du Crâne*, Paris, 1873.
[2] *Wiener Med. Presse*, 1876, Nos. ix. and xii.

such cases. Neudoerfer found in the head of a hussar, dying of pyæmia after head-injury, a portion of the felt from his head-wear firmly included within the lines of fracture. Hofmann[1] refers to the same occurrence, and once found in the fissure of a skull a piece of the dura firmly included. Friedberg has described the violent inclusion of the basilar artery in basal fissure. The most instructive examples of this kind, however, are those where particles of bullets have been found within the skull without any visible opening through which they could have entered. Bergmann describes such a specimen: the external table of the skull showed only a fissure of apparently trifling extent; not the slightest defect of the surface was visible unless one were to hold it up against the light. When thus inspected, on the inner side of the skull was to be seen a fragment of bullet of considerable size. This specimen will explain certain instances clinically reported where the internal ravages of portions of bullets have been met with, although no external sign of perforation had been discovered. There was brought into the Dorpat Clinic upon one occasion a student injured in a duel, who was unconscious, above whose eyebrow there was the mark of a bullet-wound; between the bone and the skin lay a distorted bullet, while the bone showed a depression of eight millimetres with splintered border, which, however, apparently involved only the outer table. The patient became comatose and died two days later. Upon autopsy there was found a perforation of the dura and into the brain by a fragment of bullet which had penetrated into the lateral ventricle, where it lay more or less loosely lodged; between the dura and the bone was a thick layer of coagulated blood (Bergmann).[2] Such a case as this naturally strengthens the general rule for trephining every case of bullet-wound or of compound depressed fracture of the skull.

When one diameter of the skull has been shortened and the other lengthened by application of force, the fracture may not be found at the point of application of force, but diametrically opposite to that point—in other words, at the opposite pole of the same diameter or at one of the poles of the lengthened diameter. In this way indirect fractures of the skull result. This also will explain the injuries to the brain itself, of which we shall have later to speak. Some experimental results of Perrin[3] are very instructive in this direction. When the skull with which he was experimenting lay directly upon a firm substance, the point receiving the blow was then most frequently injured; when, however, underneath the head was placed a thick cushion, the fracture was usually diametrically opposite to the injured point. It is with justice also that Baum has observed that when a man is struck to the ground by a severe blow upon the head, not only is the skull injured at the point of reception of the first blow, but also at that which comes in contact with the earth or pavement, which is often that diametrically opposite. Thus one may find two sets of fractures—one at either point and due to a different injury. (Several cases illustrating this kind of injury are reported by Bergmann, p. 121.)

Prognosis and Course of Fractures of the Vertex.—These can scarcely be considered by themselves, but possess a special interest and a

[1] *Gericht. Med.*, 1878, p. 463.
[2] *L. c.*, p. 119.
[3] *Gaz. des Hôpitaux*, 1878, p. 676.

special danger in proportion to the accompanying injury to the brain. Their prognosis, therefore, depends rather upon the condition of the cranial contents than upon that of the cranial bones. The generally-recognized greater danger of fractures of the base is due in large measure to the fact that the organic and most important parts of the brain lie upon the latter, whereas the least important functional parts of the brain are injured in ordinary fractures of the vertex. Statistics are somewhat at variance about the relative fatality of these fractures; for instance, Murney reckoned on 46 per cent. of fatalities after fracture of the vertex, and 69 per cent. after fracture of the base. According to the statistics of some other surgeons, mostly German, the greatest fatality follows fracture of the temporal region; next to this, the occipital; then the parietal; and then the frontal. The greater fatality of that first mentioned is due to the frequent injury to the middle meningeal artery. The injury to the brain is of course inflicted at the same moment as that to the cranial bones, the bone first bending, then breaking, and then inflicting harm upon the parts beneath. However, injury to the brain may follow without persistent depression or without perceptible parting of bone-fragments.

We know very well that in most cases of simple fissure the bone-margins return to their original position after having yielded and injured the parts beneath; consequently, inspection of the superficial wound gives no real idea as to the harm that may have been done underneath. A second form of injury to the brain is by splinters or fragments from the fractured area, whose sharp borders or corners may cut into or otherwise injure the membranes or the cortex. Inasmuch as we have seen that the internal table is often splintered without external evidence, we see how frequently this kind of injury may happen. Finally, a third form of injury may be produced by the absolute separation of bone-fragments and their penetration into the brain beneath. Experience has shown that almost without exception those fractures which occur with injury to the brain produce more or less bleeding between the bone and the dura. Pick[1] found that of 13 patients dying of depressed fracture of the skull, 9 showed injuries to the brain, and 3 extravasations inside the membranes, while 1 showed an extradural clot. These extravasations of course cause diminution of the cranial cavity, and consequent pressure upon the brain, to which most of the serious consequences are to be directly ascribed.

Surgeons have for a long time discussed which was the more serious —pressure from depressed bone or from effused blood. The experience of to-day seems to show that of the two the latter is much more serious. As bearing on this may be mentioned here the remarkable case reported by Cline,[2] as follows: In a naval battle a sailor was thrown upon the deck, where he lay unconscious. Later there was found a very marked depression of the skull. For fourteen months the man lay practically unconscious upon his back, with regular pulse and respiration; when he called for nourishment, it was only by moving the lips or tongue, whereupon it was brought to him. At the expiration of fourteen months Cline removed the depressed piece of bone: the operation was done at one o'clock in the afternoon, and three hours later the patient became

[1] *Brit. Med. Journ.*, 1863, No. xxi. [2] *Med.-Chir. Review*, vol. i. p. 471.

conscious and sat up in bed; in four days he left his bed, began to speak, and within a short time was practically well again. Here was a total suspension of all voluntary function for a period of fourteen months as the result of depression of bone: this could not have occurred had the pressure been due to a blood-clot. Other similar cases have been reported—*e. g.* briefly as follows: Samuel S. Cooper reports a gunshot injury to the right parietal bone; scarcely was the depressed bone removed when the almost lifeless soldier sat up in bed and soon began to speak. Dieffenbach operated on a nine-year-old boy whose head had been run over by a wagon, a portion of whose left parietal bone had been depressed. It was removed after applying the trepan three times, and immediately the previously unconscious boy opened his eyes and recovered speech and consciousness.[1]

Such cases as these have in time past brought about lively discussion of the advisability of early operation; as an illustration of which take the following statement from Dieffenbach, whose writings are not now very widely read: "A boy fell out of a window one story high upon the pavement and broke his right parietal bone, which was deeply depressed over an extent of three inches. He lay unconscious; I trephined him. He recovered, and I believed that I had saved him by the operation. A year later he fell again in the same way, and broke his left parietal bone in an almost similar fashion. This time I did not trephine him, and he recovered; and now I believed I had saved him again, and was of the opinion that the boy had undergone an extraordinary amount of interference because he survived the first trephining." Take again, Hutchinson's statement in his lectures on compression,[2] that he had never been able to convince himself of the existence of brain-symptoms as the sole result of depression of bone. Again, Textor in his writings upon the inutility of trephining in cranial depressions alludes to 12 cases—in 7 of which section was made—of positive depression of the outer and inner tables without any sign of brain-disturbance. These experiences can be paralleled by those of many other surgeons, and it is not strange that in time past they have caused a great deal of discussion as to the propriety of early operation. When we consider the fatality attending much of this work in the pre-antiseptic era, we may feel sure that the question was discussed upon its merits; at present, however, in view of clearer knowledge concerning remote results of these injuries, and in view of the ordinary harmlessness of aseptic operations, we may feel that we are depriving patients of their best chances when we neglect to operate, no matter what past records may show.

This naturally brings up the question of remote results of injuries to the head. It was, perhaps, Broca[3] who first called attention to the disturbances following depressions where healing was supposed to have been perfect, he being quickly followed by Busch,[4] who elaborated upon the same theme. Since that time a mass of literature has accumulated, all pointing toward the frequently unpleasant, and therefore seriously untoward or even fatal, results of neglected head-injuries, these being partly of a neuro-psychic character, and partly of an infectious type,

[1] For further illustrations see Bergmann, p. 126.
[2] *London Hospital Reports*, vol. iv.
[3] *Gaz. des. Hôp.*, 1867, p. 123.
[4] *Arch. f. klin. Chir.*, vol. xv. p. 46.

such as abscesses, etc. Of these disturbances more will be said under another heading: it is enough to say here that it would be much wiser in the long run to subject every traumatic depression of the cranial bones to operation than to fall back upon certain fortunate cases recorded in literature as an excuse for non-interference.

Aside from the infectious consequences of these injuries—alluding for the most part to ostitis and osteomyelitis, already spoken of, or to intracranial abscesses, to be described later—the results of fractures of the vertex are for the most part confined to the fate of the fragments of bone which may have been partially or completely separated at the time of the injury, yet not removed. These frequently necrose, and either separate spontaneously as sequestra or have to be removed by subsequent operation. The extent to which loss of bone-substance may occur in some of these cases is remarkable. Schneider has described a man who lost fully one-fifth of the bone of his skull by necrosis following injury. Nunn[1] reports a two-and-a-half-year-old child who, as the result of a blow upon the head, had very extensive necrosis of the parietal region, one sequestrum measuring four inches in length and two others each two inches, and all this without the slightest brain-disturbance. The separation of sequestra may occur in all sorts of ways, and they may be removed from considerable depths, as toward the base of the skull. Sometimes these are perforated, as, apparently, for previous escape of pus from beneath them. Pott has described quite a classical form of skull-necrosis with formation of pus between the bone and the dura, by which the membrane is completely separated from the bone. This is the later result of a form of contusion of the bone described by him and already referred to.

Fig. 421.

Case from the author's clinic: result of old injury, with loss of one parietal bone and sloughing of brain.[2]

Van Swieten relates the case of a beggar-woman who lost half her skull by accident, and who was in the habit of carrying the bone about from house to house. If the finger were pressed on the dura, she screamed aloud and said she saw "a thousand lights."

In the repair of these injuries we have practically no provisional callus produced, as is the case in long bones, while the definitive callus is but slight in amount and met with only between the bone-edges, as is the case in the other flat bones, like the scapula and the pelvis. Thus it appears that the bones of the skull and their periosteal coverings are not in a general way disposed toward new formation of bone. There is every reason to think that were more of provisional callus thrown out in

[1] *Trans. Path. Soc. London*, 1864, p. 205.
[2] *Med. Press Western New York*, Aug., 1888, p. 317.

these injuries we would have fewer cases of necrosis and similar untoward results to deal with. It seems almost absolutely necessary to have the bony margins in fair contact in order to get enough new bone to make an ideal union. Moreover, the callus-formation does not seem to go at all beyond the limits of the periosteum, and one never sees anything like the exuberant callus which is so often met with in the limbs. The dura seems to participate more in this formation than the pericranium; it has been found that loosened fragments are more apt to be bound together by callus on the inside of the skull than on the outside.

(Bergmann has figured a skull from the Leipsic collection, which shows a very perfect formation of flat osteophytes in connection with the dura. This condition, however, is very rare.)

The *Surgical History of the Cival War* refers only to one case of hyperostosis after gunshot fracture of the skull: the patient was injured in 1864, two years later became epileptic, and in 1871 was trephined with good result; the portion of bone removed was nearly an inch thick. Emmert[1] removed a hyperostitic portion from the frontal bone of a man who six years previously had been injured by a shovel, sustaining a fracture of that bone.

As a further consequence of the relative unproductivity of the periosteum of the skull, one finds that about all callus that is met with comes from the diploëtic structure. It is so also in the scapula. The productivity of this layer of bone has been studied experimentally by numerous observers—among the most prominent by Ollier,[2] from which it would appear that the pericranium does but little in these cases by granulation, the granulations perhaps later ossifying, whereas the true bone-forming material comes almost entirely from the marrow-tissue of the diploë. The first result of callus-formation is the complete bony closure of fissures and of small openings, although it takes place relatively more slowly than in other parts of the body. Bruns has quoted observations by Conradi and Boinet,[3] from which it appears that four months after injury fissures may be scarcely closed, and that even a year and a half later a long fissure extending from the parietal to the occipital bone was not completely ossified. However, it is satisfactory in this respect that healing almost always does ensue, and that every collection of any size gives abundant evidence of the fact that fractures of the skull are capable of absolute and complete reunion.

So far as the greater productivity of the internal table is concerned, there is particular evidence of the same in the reunion of completely-separated bone-fragments. It has been established by numerous observers that fragments of the vitrea which have been absolutely separated or partially so do not die, but in some way secure nourishment, and later reunite with the main bones. Among numerous reports of this kind there is one by Beck, who found in two cases a penetrating wound in which pieces of the inner table were broken loose, and that these were completely united with the dura by a plastic exudate. Again, Demme has described the following case: In 1849 a wounded Hungarian soldier died in Italy of typhoid. Under a depressed area of his skull were

[1] *Lehrbuch der Chir.*, 1860, vol. ii. p. 69.
[2] *Traité de la Régénération des Os*, 1867, p. 285.
[3] *Arch. gén.*, 1837, vol. ii. p. 337.

found two completely-separated fragments of bone encapsulated in the dura, one being fifteen lines long and the other twelve.

It is evident that observations such as these have a significance of their own, because when so many instances of necrosis and deep infection, usually fatal, are known to follow the injuries above described, it is well to remember that it is possible for splinters to become reunited or encapsulated—in other words, to be made harmless without further disturbance. It is, moreover, extremely likely that there are many more of these cases than is generally appreciated in which recovery has followed, and whose right character has never been discovered. Huguenin[1] found in the body of a man dead of typhus a splinter of the vitrea without perceptible lesion of the external surface of the bone: this man had fallen five months previously from a wagon, and had suffered for some little time with the customary disturbances of brain-commotion; even at that time it could not be told upon what part of the skull he had struck. The autopsy showed that a piece of the inner surface of the frontal bone, $\frac{1}{2}$ by 1 centimetre, had been completely separated and had perforated the dura; there was some yellow softening of the cortex, but absolutely no indication of meningitis or encephalitis.

Fractures with loss of substance heal only exceptionally by anything like complete repair. As a rule, there are deficiencies which are covered or filled only with membrane, ossification being imperfect and irregular. Most of these injuries heal about as do trephine openings. We are justified in holding, then, that a complete bony repair of defects of this kind is a rarity, and that defects covering an area of more than six by eight centimetres can scarcely be expected to heal in this way. Gudden's experiments on the skulls of animals are quite instructive in this direction. He found that when the edges of a freshly-made fracture lay in close contact there were synostoses, but that when there was some little defect between the borders the reunion was only partial or sometimes very defective.[2] He found also that in some cases of loss of bony substance there were granulations produced from the dura which participated in the membrane which closed the defect, and which were adherent by a sort of connective tissue with the arachnoid beneath or even with the cortex of the brain.

Diagnosis of Fractures of the Vertex.—In simple fractures there is practically but one method open to us: the local examination must be made with the finger outside of the soft parts, while a study of the general condition of the patient may lend corroborating or distinctive signs. With the finger we seek to detect differences in level—*i. e.* depressions or possible fissures whose margins are separated or whose levels are altered. Obviously, there must be physical differences of considerable extent before the palpating finger upon the skin without can detect them. In this connection we must emphasize the possibility of mistake of some older or possibly congenital lesion for the effects of recent injury. Plattner[3] long ago related the case of a man who had fallen, was picked up unconscious, and in whose skull there was an evident depression; he was prepared for operation, but, recovering consciousness before it was performed, related how this was a peculiarity dating back

[1] *Ziemssen's Handbuch.* [2] *Untersuchun. u. d. Schädelwachsthum,* 1874.
[3] *Institut. Chirurgiæ,* 1758.

to his youth. Mistakes occur also sometimes in regarding the effects of atrophy or of other nutritive disturbances as due to injury. Cooper[1] has related how a man of forty-one had suffered seven years previously from an injury to the head, followed by hemiplegia. He was operated upon and died of secondary hemorrhage, after which it was found that the depression upon which so much stress had been laid was due to atrophy of the bone. Mistakes may also occur in the skulls of syphilitic patients, in whom, as is well known, the disappearance of a gummy tumor is often accompanied by absorption of the compromised bone. Finally, must be remembered the effects of congenital or acquired asymmetry, as the result of which we get skulls occasionally of peculiar form or presenting peculiar irregularities, which in the excitement of the moment may easily be mistaken for the results of traumatism, or when presenting superficial lesions which call particular attention to them. The history of these cases, when it can be secured, the existence of old scars, or the possible symmetrical arrangement of the skull by which a similar defect or prominence may be found on the other side, or the evidence afforded by distinct syphilitic lesions, will usually enable one to guard against errors of this kind.

Very much more frequently mistakes arise in the difficulty of appreciating the deeper condition through the injured and swollen superficial soft parts. Every surgeon has often been in doubt as to whether a depression in the soft parts really overlaid a distinct depression in the bone or not, and incision or other investigation has often been made to clear up this uncertainty alone. Incisions are perfectly justifiable when made for this purpose, providing aseptic precautions be observed. Still, it may often happen that one may get sufficient information by the use of a needle, with which the level of the bone can be easily ascertained. Certain it is, however, that an area of infiltration of blood with its somewhat abrupt margin may lead even the elect into error. When the patient is conscious he may be able to give important information, and especially his sensation of pain when pressure is made is of value, since he will be much more likely to complain when pressure is made over really depressed bone than when otherwise. The pain is usually as well located in these cases as in a limb when one of the long bones is broken. In spite, however, of all aids to diagnosis, it is certain that not a small proportion of actual fractures of the skull go undetected. Many of these patients recover, while some of them come to the dissecting table, usually brought there by brain-complications or other intercurrent affections. Bergmann is, for his own part, convinced that many children recover from fractured skull in whom it is sometimes not even suspected at all. So long as the fracture is purely a simple one, its exact determination is a matter of scientific interest rather than of clinical necessity, the treatment being mainly that for whatever injury may have been received to the soft parts.

A peculiar result of subcutaneous fractures of the vertex, which is especially observed in young children, is the development of a more or less circumscribed tumor, filled with fluid, located under the soft parts of the skull. This is in large measure of the kind already alluded to as described by Pott. This fluid, however, is in the cases alluded to not

[1] *Am. Med. Times*, 1862.

pus, but usually cerebro-spinal fluid. This accident presupposes injury to the dura as well as to the arachnoid, through which opening this fluid may escape. Another possible explanation is afforded by the presence of those cysts in and about the skull which are well known to exist either congenitally or as the result of alteration in blood-clot. Rokitansky has paid considerable attention to these collections of fluid, and regards them, for the most part, as of the latter variety—*i. e.* results of blood-clot, which he says may be more easily explained when we remember the rich vascularity of the bones in children and the ease with which arterial branches may be torn, especially when they cross the sutures.[1]

When the soft parts are so far disturbed that access may be had to the bone, then diagnosis is about as simple as it can be made: simply with the finger, or often with the eye, a solution of continuity may be appreciated. However, it does not always happen that the fracture lies visible at the depths of the external wound. Moreover, there may be roundabout connection between the cranial cavity and the outer wound as the result of lacerations or separations of continuity, so that cerebro-spinal fluid may escape. When this is noted it points practically invariably to fracture, even though this itself may not be perceptible. Sometimes also brain-matter may appear. It does not always follow that that which may at first seem brain-matter is really such, since Quesnay[2] quotes Marechal as mistaking, in one case of fracture of the frontal bone, for brain-substance that which proved later to be the contents of the frontal sinus. In certain cases it may be noted that the fluid used for irrigating and cleansing, with which a wound has been filled, begins to pulsate. This means, practically always, connection with the cranial cavity, and consequently fracture. Sir Prescott Hewett relates the following incident, which is worthy of reproduction here: A physician withdrew from a wound of the skull a piece of bone of considerable size, and beneath where it lay could feel with the finger an opening in the skull; his diagnosis was instantly made, as would ordinarily be natural. But it appeared a little later that the extracted bone was not human bone, and that the opening in the skull was merely a perforation of the temporal fascia. It seemed that the patient while walking upon the street had fallen upon a piece of bone, which had penetrated the bone and fascia and was withdrawn as above.

Aids to diagnosis are more at hand when by the injury the seat of fracture is more or less widely exposed. Difficulties or errors may arise in discovering minute fissures, which may perhaps have been diastases of sutures, since these may be mistaken for the sutures themselves, for grooves for vessels, or for imprisoned hairs. So far as the sutures are concerned, a knowledge of their location will guard against this error. Hippocrates himself mistook for a fracture the suture between the two halves of the frontal bone; and there is on record the well-known anecdote of Saucerotte, who protected a patient from an operation for trephining because he discovered that the alleged line of fissure was only the line of suture between the occipital bone and an enlarged Wormian bone. The grateful patient left him his skull as a legacy.

Information may sometimes be obtained as to the degree of splinter-

[1] *Vide infra,* on Intracranial Tumors. [2] *Mémoires de l'Acad. de Chir.*, vol. i. p. 247.

ing of the internal table by the use of a fine probe through the openings, by which the depth to which it is depressed or its motility—*i. e.* its separation—may be made out. But cases in which this method can be resorted to are quite exceptional. We may always be guided by an accurate account of the injury, since it is a safe rule to follow that the more localized the effect of violence and the narrower the limits of the fracture, the more probable that the inner table is broken into fragments somewhat corresponding to those of the outer table.

Diagnosis of isolated fracture of the inner table is practically out of the question. Macchisi has suggested that for this purpose we resort to percussion of the skull with some metallic instrument, claiming that at a point overlying the injured inner table the percussion-sounds will vary from those obtained over other parts of the skull. A much more fanciful suggestion of Sédillot was to listen for sounds that might be produced by friction between the dura and the fragments. It has been suggested also that a surface thermometer would show an elevated temperature over the area of injury; this, however, is very questionable. In one case, however, Stromeyer made a brilliant diagnosis of this injury, noticing that so soon as his patient assumed a horizontal position he began to vomit. On autopsy it was found that there was a depressed splinter of the inner table which had perforated the dura; in the upright position this membrane and the cortex were less irritated than when the skull was more completely filled by the congested brain in the horizontal position.

When the bone is broken into numerous fragments or splinters recognition is easy, and about the only doubt that can arise is with regard to the direction and extent of fissuring and the injury to the parts beneath. Doubts of this kind are to be cleared up mainly in the course of the operation which is obviously indicated, and efforts at determination may be postponed until the operation is under way. Prognostically of value is the unbroken dura: so long as its integrity is undisturbed the condition within is less likely to be unfavorable; on the contrary, protrusion or prolapse of brain-substance is always a most serious complication. Escape of cerebro-spinal fluid happens relatively seldom in fractures of the vertex. Bergmann takes note of at least fourteen cases of this kind, in some of which autopsy had been made. In most of these latter cases it was found that fluid escaped from one of the lateral ventricles; and this fact is of value as shedding light on these cases in the future. In one of Hewett's cases four and a half ounces escaped in this way in twenty-four hours.

The Treatment of Fractures of the Vertex.—Treatment of these cases is practically summed up in—or at least is secondary to—the treatment of such injuries as may have happened to the soft parts without, or more particularly to the brain and its membranes within. In a general way we may divide it into—

1. Treatment of subcutaneous fractures; and

2. Treatment of compound fractures, often with considerable injury to the soft parts.

1. So far as simple fractures are concerned, the treatment must be, for the most part, expectant, or at least symptomatic. So long as no operation is called for to relieve depression, the treatment is of the

simplest possible character. When, however, we have fracture with depression, even though the external parts be not severely injured, the treatment becomes at once operative, and for reasons considered in various parts of what has gone before. Without reference to those cases collected from literature in which recovery has been shown to follow even a serious depression, and without reference to the writings of men like Textor, Hutchinson, and others concerning the inutility of trephining after simple depressions, we have to-day the verdict of all advanced surgeons the world over that it is not merely justifiable, but it is really the best practice, to cut down upon the depressed bone and elevate it. This justification comes to us from many sources and for many reasons. Aside from those which are self-evident at the time, there are those which experience has taught us with regard to the secondary, often the remote, consequences of these lesions; and by the best and most judicious operators of to-day it is generally received as a well-established doctrine in surgery that it is much safer to properly operate on these cases than to allow them to go unattacked. In fact, when this operation is thus done the writer holds that we may teach that the operation itself is not so dangerous as failure to relieve in the presence of so plain indication. The less serious the condition revealed, the less the danger of the operation; and, on the other hand, the greater the disturbance whose detection the operation permits, the greater the danger of leaving the case unoperated. More will be said about this phase of the question when discussing the surgical treatment of epilepsy and kindred disorders.

2. The second category of cases—those in which there are compound injuries—calls practically always for operation of some character, either mild or severe. Here it is most important to remove loosened splinters, as well as to excise and get rid of all tissue, soft or bony, whose vascular supply has been so far interfered with as to make its nutrition doubtful. This of course means that these cases call for the best of trained surgical judgment—a statement, of course, which no one will controvert. Furthermore, all sharp splinters and anything which can irritate the dura or the cortex must be removed; sharp edges or projecting fragments must be rounded off, and all penetrating foreign bodies, if possible, removed. When it seems a measure of doubtful propriety to close such a wound with the view of obtaining primary union, the attempt should be given up: the wound should be packed with gauze and temporarily closed with secondary sutures. In this way many lives may be saved which would be sacrificed to more ambitious attempts at union by first intention. Furthermore, all these primary measures should be ably seconded by those efforts which every judicial surgical man would calmly decide upon. These include physiological rest, attention to the primæ viæ, the avoidance of transportation, which has brought about many fatalities in military practice, the local application of cold, and everything else which a good clinician may consider would make his operative efforts of greater value.

The fractures with overlying injury to the soft parts are in many respects simpler, so far as indications for treatment are concerned, than some of the subcutaneous fractures. For the most part tissues are so exposed that one can see his way pretty clearly as to just what ought to be done. With regard to extensive fractures of the bones, and those from

which there has been actual loss of substance, the treatment is practically not different from that necessitated in simple external contusion, except so far as the necessity for trephining or its equivalent operation is concerned. Even so far back as 1830, Pirogoff was teaching that the injury to the bone should be treated much as one would treat injury to soft tissues; the bone itself was to be removed only to the extent that the eye or the finger determined that it was loose or depressed. The examination by which this condition was to be established was only a part of the procedure necessitated for cleansing and examining the external wound. When, later, the idea took ground that it was possible for even a compound fracture of this kind to heal without suppuration, the method of treatment was somewhat altered: sutures were more freely used and dressings were allowed to remain longer. At present we go almost as far as imagination can permit in the direction of efforts at primary healing and at complete closure of suitable wounds. Virtually, it is all summed up in the statement that everything which can cause disturbance is removed to at least a safe distance, that absolute surgical cleanliness is insisted upon, and that many of these extensive injuries heal, when this has all been done, by first intention. This is a small part of what we owe to the doctrines taught by Lister.

There is, however, just as much occasion for good judgment under the present conditions as ever existed in the past. This will be shown in the selection of the amount of bone to be removed; the method by which it should be done; the wisdom or otherwise of opening the dura—possibly even the deeper examination of the brain itself; the trimming away of all soft tissues which have been compromised sufficiently to affect their viability; the carrying out of some plastic method, if necessary, for closure of the defect; the matter of drainage; the method of closing the wound—*i. e.* whether it shall aim at primary or secondary union; the character of the dressing; the length of time it shall be allowed to remain; and, in a general way, the management of the patient in other respects. In other words, the treatment of compound fractures of the skull differs in no essential respect from that of compound fractures elsewhere: it is modified only by the character of the important organ contained within the cavity of the skull. In many respects it is much easier than compound fractures of the long bones, and it is made more dangerous only by compromising injury of the brain beneath. One may hold, in a general way, that the bone-fragments should be handled to the least possible extent, and that any unnecessary disturbance of them is a positive detriment to the patient. On the other hand, there is equal necessity for removing every splinter or fragment which can irritate or in any way do harm. When drainage is resorted to, it is seldom necessary to extend the tube between or beneath the bones: it is sufficient usually to drain the scalp-wound. In one respect, however, these skull-fractures differ from those of other parts of the body—namely, that there is wisdom in early and sometimes in frequent change of dressings; the slightest retention of pus or other products of decomposition might set up meningitis, and is consequently even more dangerous than in some other parts of the body. When we remember that purulent meningitis may be fatal within thirty-six hours after reception of the injury, one may see the necessity for immediate interfe-

rence and the wisdom of early inspection of the parts. In some cases, especially those noted by military surgeons, this meningitis spreads with amazing rapidity from the convexity to the base, and even down the spinal canal to its lowest extremity. Bergmann relates[1] such a case, where a soldier, dying thirty-six hours after injury to his head, was found to have not only a cerebral meningitis, but on removal of the lumbar vertebræ the infection was found to have extended even to the cauda equina. This seems to be one of the quickest cases of this kind, if not the most so, on record, and has a terrible significance.

Skull-fractures in which the injury is limited to a small area almost always present stellar or splintered fractures, usually depressed, which call always for the use of the trephine. Were it worth while, a great deal of space could be devoted here to a repetition of discussions which have been held in various surgical societies in time past with regard to the early use of the trephine. Except as a matter of medical history, it would seem to me a digression without advantage: the advance in our knowledge of endocranial surgery has been so great that most of the dicta and directions of the older authors must be either disregarded or rewritten. The writer, therefore, fears no contradiction from modern surgeons in advising early and frequent, but not indiscriminate, operating in these cases. In spite, therefore, of Bergmann's advice that a short fissure and a limited depression should be left alone, I cannot but feel that in the long run such cases will be much better off if *careful and judicious operating* be advised in every case where distinct depression can be made out, or in every case where any indications point to an injury to parts within the bone. In this same direction one may say also that statistics of these operations in time past have, perhaps, a melancholy interest for us now, but very little of real instruction. What is it to us, except as a painful regret, that, for instance, of 923 trephinings reported from one source, 473—*i. e.* $51\frac{2}{10}$ per cent.—died? One may claim that to-day, if the operation be properly carried out, it may fail to save a certain percentage of cases which nothing can save, but that it should not be followed by 1 per cent. of mortality except as this may occur possibly from the element of shock. There are many of these head-injuries in which trephining is legitimately resorted to as a humane effort to save life, a *dernier ressort*, but that it should ever kill by itself is most unusual. The writer feels very strongly on this matter that the public generally should be set right, and that it should never be allowed without protest to speak of such an operation as this killing the patient, but that it should be stoutly maintained that it simply failed to save; in other words, that patients may die in spite of it, but rarely in consequence of it. That the mere operation by itself is comparatively trivial, the history of the past, even in pre-antiseptic days, fully establishes. There is, for instance, the celebrated case reported by Stohlpart van der Wiel of the duke of Nassau, whom he himself trephined twenty-seven times, and after the last operation had the satisfaction of seeing His Highness live for many years.[2] There is so much else in recent literature concerning the antiquity and ubiquity of this operation that it would seem unnecessary to say anything more about it here.

Enough has also been said about disturbances which may follow these

[1] *L. c.*, p. 174.

[2] *Observat. rar. cent.*, Lugduni, Batav., 1728.

injuries to make it unnecessary to do more than to refer the reader to other parts of this section; for example, to the subjects of epilepsy, phlegmon of the soft parts, and thrombosis, meningitis, intracranial abscess, etc. Under each of those headings the facts have been stated that they are most likely to follow injuries under present consideration, and to them the reader can be safely referred.

The separation of sequestra by granulations may be complicated by exuberance of the same, by secondary hemorrhage, by further necrosis, or by acute suppuration. As a rule, loose particles or laminæ of bone are easy of separation. Where necrosis is extensive the bone-margins die as well as the central portion, and the spontaneous separation may be a very tedious process, requiring to be much abbreviated by operation. So soon as exfoliation or extraction is accomplished, healing and cicatrization quickly follow. Underneath these sequestra it is possible for pus to collect in such a way as to irritate the dura or even produce brain-symptoms. In all respects, therefore, it is wise, unless some particular indication contraindicates, to hasten the process of spontaneous removal by operation at the earliest feasible date.

Of all the fractures of the skull, those which in time past have by common consent been regarded as most necessitating operations are gunshot fractures, which rank first. These, however, are treated of in another portion of this work (Vol. I.), and hence have received but little notice here. They are mentioned now only to emphasize the importance of the indication which they offer, as well as to again remind that these are the injuries most likely to be followed by splintering or depression of the inner table. As a rule, and unless perforating injury to the brain has occurred at the same time, they are, when properly operated on, of favorable prognosis.

The question always comes up in these cases after attending properly to the bone, How much exploration or interference should be made in the brain itself? The record of thousands of fatal cases shows how often particles of bone or lead are carried along the bullet-track and left in the brain; the inference from thousands, again, of cases followed by recovery would indicate, on the other hand, that the deposition of such particles as these, or of such minute fragments, is by no means of itself necessarily fatal, and that such as do not present easily and are not discovered with a minimum of exploration may be more safely left than hunted for. It probably is best to say, as the safest rule to follow, that only those which appear on or near the surface call for removal. This is largely in accord with the modern treatment of gunshot wounds, based upon the principle that the harm done by a bullet is done during its flight, and that so soon as it is lodged it becomes to most intents and purposes a harmless if a foreign body. Of course in all this there is no intention of advising against the operative removal of the bullet itself, probably from some other part of the skull, should either subjective or objective symptoms indicate its presence or its removal. Gross, who saw eight cases of injury to the middle meningeal by gunshot wounds, came to the conclusion that this was an injury which in military practice was less often complicated with severe lesions of the brain than in civil.[1] Therefore, with what little has been said before on this point it will be

[1] *Amer. Journ. Med. Sci.*, July, 1873.

readily understood that the limit of usefulness of primary trephining in penetrating gunshot wounds of the skull is restricted, and generally to those cases where the bullet or the bone-fragments have not been deeply driven, but remain for the most part superficial.

Fractures of the Base of the Skull.

The cranial base may be regarded as in a measure protected by the bones of the face in front and by the musculature of the neck in the rear; in spite of which protections, however, it often sustains severe injury. For the most part, the violence is applied at some more or less distant point, and the bone is broken at the base by transmission of the same through the arches and the well-known construction of the skull itself. The most frequent location of this indirect injury is the convexity of the skull; much less frequently is violence applied from below or from other directions. In other words, fractures of the base of the skull are in large degree indirect, and the mechanism of such indirect fractures deserves at least brief discussion. They have been recognized ever since medicine had a history, but adequate conception of their real mechanism has been a matter of comparatively very recent origin. They have been compared to the echo following the original sound, inasmuch as the first injury is applied to some other point; in fact, this comparison, ascribed generally to Paulus Ægineta, is the origin of the teaching of fracture by *contrecoup*.[1] The more outspoken idea implied in this last phrase is due to the teachings mainly of the French surgeons, particularly Saucerotte, Grima, Sabourant, and Méhée de la Touche, in communications made to the Paris Academy of Surgery between 1760 and 1774. According to these writers, the violence of the blow was transmitted until it found its final expression in lesion of the bones of the base, the supposition being that violence was transmitted around on opposite sides of the skull until a point was reached where the waves met, at which point the continuity of the bone was broken. This was the generally-received idea until Aran took ground against this teaching, because the fractures could not be thus produced in experiments on the dead body. According to him, all basal fractures were fractures by irradiation: the fissure never took its origin from the point of first impact, but travelled in the shortest direction of least resistance from that point to the base. Trelat in a memorable communication to the society agreed with Aran, while both teaching and experience accumulated to the effect that it was not a contra-fracture with which we have to deal in these cases, but an irradiated. But again opinion changed, and it was found in some of these cases that diametrically opposite the point at which injury had been received the skull was broken, while the brain-substance also suffered in the same way, as though that diameter of the skull had been forcibly diminished. And then men dropped back on the opinion, expressed among others by Bruns, that the secret of these fractures was to be found in the elasticity of the skull, and that the ex-

[1] Félizet has also compared the mechanism of these fractures to that of forcing a hammer-head up on its handle. This can be managed by striking in two different ways. *Vide* also Greder, "Experimentelle Untersuchungen über Schädelbasisbrüche," *Deutsche Zeitschft. f. Chirurgie*, xxi. 491.

planation was practically the same for these cases as, for instance, in the case of a patient who has received a violent blow or compressing injury upon the chest, when it was found not infrequently that the ribs are broken at some other point, usually one opposite to that of the primary injury, and that not infrequently the lungs or other soft parts have suffered, as does the brain suffer in the cases before spoken of. Something of the same kind has been described also by oculists as occurring in the eye, so that when the globe is struck between the corneal border and its equator the retina or choroid is torn at a point diametrically opposite. The same thing occurs also in the pelvis, and something similar, but less distinctive, may be met with in ruptures of the bladder or other viscera. In England for some time men followed Earle and Brodie in holding that it was not merely the mechanism before alluded to which could explain these cases, but that the skull in such instances was really compressed between two resisting objects—the vertebræ below and that which caused the violence above—and they sought to explain fractures of the base on the theory that the condyles of the occipital bone were more or less driven into the skull by its impact upon the spinal column. It was on this ground also that Hilton explained the frequency of fracture of the petrous portion.

Much time and pains have been devoted by numerous investigators to the elucidation of facts thus briefly alluded to. Application of the ordinary laws of mechanics has been more carefully made, and the skull has been studied as an architectural work, in order to better appreciate the lines along which its construction is most strengthened and along which violence may be most distinctly transmitted. In 1813, Kuettingler voiced the idea that a blunt ovoid or bullet-shaped skull seemed to possess more resistance than a square and flat one—a fact which has received considerable experimental and clinical proof since that time, but for which Félizet seems to have given the first adequate explanation. General observations agree that particular portions of the base seem more resistant than others; that is, that lines of fracture are more frequently found in certain areas than in others. While this is undoubtedly the case, still it does not yet appear that there are inviolable laws which can be appreciated as governing the occurrence of these fractures, since so many elements conspire to produce individual differences in skulls. It seems to be a pretty general rule that when the violence has not been excessive, but in a measure extensive, the lines of fissure extend toward the base through those parts of the skull known to be most weak—in other words, between the architectural pillars of the skull. Were the skull everywhere equally thick and elastic, it would be relatively easy to determine at what point we could expect injuries in a given case. This, however, is true to such a slight extent that only in a general way can we draw certain deductions. From a general study of mechanics we know that these tears or separations usually extend between the most resistant parts; and so in violence applied upon the forehead we usually find that the fissure extends between the crista and the wings of the sphenoid on that side in its course toward the base, while when the lateral region of the skull is injured the fissure commonly extends between the sphenoidal wings and the petrous bone; and, lastly, when the occipital region is injured the fracture lies usually between the

pyramid and the occipital crista, upon either one or both sides. This seems to be the most common result, as judged both by clinical observations and experiments upon the cadaver.

In 1884, Aran[1] first published his results as deduced from investigations of the cadaver. He found that that part of the skull which first came in contact with the body which struck it or upon which it struck gave a key to the direction of the fracture. His conclusions were as follows:

1. The great variety of indirect fractures (so-called *contrecoups*) are in reality fractures propagated from the vault to the base—*i. e.* fractures by irradiation.
2. Fractures reach the base by the shortest anatomical route, traversing fissures in their course.
3. There is a relation between the region of the skull injured and the seat of the basal fractures.

He was unable to produce a distinctive fracture by contrecoup.

This is, in effect, not widely varying from the statements made by Félizet. According to Aran's views, most authors divide the base of the skull into three areas, corresponding well to the three fossæ of English anatomists, and it is found that in violence applied to the anterior part of the skull a fissure is usually found in the anterior fossa, and so with regard to each of the others. Hewett took the pains to study 68 fractures of the base, investigated at St. George's Hospital, with regard to the accuracy of Aran's statements. In 36 per cent. he found that they were true. Bergmann found that 39 per cent. of cases followed Aran's rule. Combining Hewett's and Bergmann's statistical cases, it was found that 12 per cent. concerned alone the anterior fossa, 43 per cent. the middle, and 15 per cent. alone the posterior. The frequency of fracture of the middle fossa is explained by the larger distance between the temporal and parietal fissures, and because falls on the temple are exceedingly common. In 102 studied cases the fissure extended in 69 cases into two fossæ. In the majority of basal fractures the petrous portion of the temple is involved; Félizet made this out definitely from studying the cases in the Musée Dupuytren. At all events, the typical cases of Aran and Félizet remain in the minority; the majority of basal fractures follow no predetermined rule.

There is more to be taken into account than the size, velocity, and direction of the impinging object, as Weber's experiments have shown. With a skull swinging freely blows with a hammer were seldom followed by a fracture, but so soon as the skull was firmly fastened blows were followed by fissures extending even to the base; and, inasmuch as the skull rests upon the vertebral column, it has more or less of a fastening corresponding to that of Weber's experiments, and the result must be in large measure analogous. The direction of basal fractures into the middle fossa is, as a rule, transverse, since they usually make a more or less rude right angle with the long diameter of the skull. In general, one may assign two localities in which they are most common; the one lies parallel to the long axis of the petrous bone; the other is found in the vicinity of the great wing of the sphenoid. Those which involve

[1] *Arch. gén. de Méd.*, vol. vi. p. 180.

the petrous bone often extend through the root of the zygomatic process. The so-called longitudinal fissure of the petrous bone is one of the most common results of a blow upon the side of the skull; at least it occurred in 17 out of 21 cases cited by Honel. These fractures are often complicated with fractures of the zygomatic process or diastases of one of the neighboring sutures. Their mechanism is comparatively simple: every blow applied to the lateral surface of the skull is followed by violence transmitted in two directions, one of these being toward the limiting props or buttresses of the skull, and the other toward the base. In the lateral region, for instance, the first takes the fracture in the direction of the anterior lacerated foramen, the second in that of the spheno-orbital fissure.

One of the most valuable clinical studies of head-injuries made for many years was made by Chas. Phelps, and published in 1893.[1] In his experience, 60 per cent. of severe injuries to the head involve fracture at the base. He claims that fractures of the skull which do not begin at the vertex and extend to the base are exceptional, and that he has found only four cases in which fracture at the base was not continuous with a fissure extending from a point upon the vertex at which the violence was inflicted; these four were evidently from contrecoup. He claims also that fissures extend from vertex to base, and not in the reverse direction; which is often proved, even in the absence of history, by the mute evidence of the superficial injury and by the narrowing of the fissure as it passes downward.

Phelps reports one instance where the temporal bone was separated into its constituent parts, in an adult male, from apparently inadequate cause; the only case on record of this character that he knows of. He reports a case also where all the fossæ on both sides were involved, the patient having fallen from a masthead and survived two hours. This, he thinks, is the first case on record in which all the fossæ were involved. With Stimson and others, he insists on differentiation between *bursting* fractures and *circumscribed* fractures; that is, those due to multiple forces and those due to individual forces. In the former we have very long linear fractures with or without depression, with the line of fracture running into the base, where operation is of no value.

Some important studies were made on the subject of the etiology of fractures of the skull in 1888 by A. W. Hare.[2] Since the same laws govern large and small bodies alike, Félizet's proposal to divide fractures into those produced by great violence and those by small is unjustifiable, for the way in which the force is applied is important. In a diffuse blow there is less tendency to fracture at the seat of application than at some distant point. The theory of contrecoup should apply rather to spheres of uniform strength and of regular structure, but scarcely to a construction like the skull. Fissures pass to the base and involve it in the fracture, taking, according to Aran, the nearest route; while, according to Félizet, they do not take the nearest route, but pass downward between the bony buttresses described by Hilton. When Schwartz published the results of a series of experiments it was seen that he found that on applying force to the side of the skull fracture of the base constantly occurred in the middle fossa and in a direct parallel to the parietal portion of the

[1] *N. Y. Med. Journ.*, Jan. 14–28, 1893. [2] *Lancet*, Feb. 4, 1888.

temporal—*i. e.* parallel to the line of force producing the injury. Similarly—in other parts of the skull, that is—the line of fracture is parallel to the line of force.

After remaining comparatively unnoticed for several years, these results were tested in 1880 by Messerer,[1] and in 1881 by Hermann,[2] and both arrived at the same results, by which these fractures are to be looked upon not as the result of radiation, but of compression or bursting. Hare found, experimentally, that by applying force gradually one could watch the fracture develop itself, commencing in what represented the equatorial zone of the base—*i. e.* midway between the points of pressure—and extending as more force was applied in both directions, parallel to the line of force toward the poles at which it was applied, until he obtained exactly the same appearances as those upon which Aran based his radiation theory. So Hare claims that the appearances produced in Aran's experiments were due to the excessive amount of force used. Von Wahl[3] accepts this view, and gives sixteen cases of fractured base from the Surgical Museum of Dorpat which seem to bear out these views. Hare himself, as well as others, has reported cases which would also substantiate this view, and considers that he must practically adopt Von Wahl's theory, that the fracture occurs in the line in which force is applied or parallel to it. In other words, he would accept Aran's experiments and results, but would modify his interpretation of them. This modification would be a trivial matter, were it not for the importance of the clinical issues involved, since, if we can by applying the law of parallel cleavage define the course of cranial fissures, much is done toward removing that uncertainty which is the great barrier to logical and successful treatment. (Plate V.)

Hare sums up his views as follows: Diffuse blows produce their chief effect at a distance from the point of application; those struck on the vault produce fissures in the corresponding segment of the base; those struck on the back produce fissure-fractures on the base of the skull parallel to the force applied.

Thompson, too,[4] following Dolbeau and Félizet, has called attention to the fact that the skull does not conform to any fixed mathematical figure, but is composed of bones varying in shapes and density, with connections of varying firmness. As a result, much violence is expended in stretching the union of sutures, so that, in youth at least, a crushing is attended by rather a diastasis of the sutures than fracture of bone.[5] He calls attention, as did Hilton, to the peculiar fractures of the skull where certain parts have greater strength and massiveness than others. These parts serve as buttresses to unite vault and base into one solid framework. One buttress is represented by the frontal eminence abutting below on the ethmoid, and continuing in the middle line of the vertex to the posterior buttress, which passes through the occipital protuberance. The temporal and parietal regions form the lateral but-

[1] *Ueber Elasticität u. Festigkeit der menschlichen Knochen*, Stuttgart, 1880.

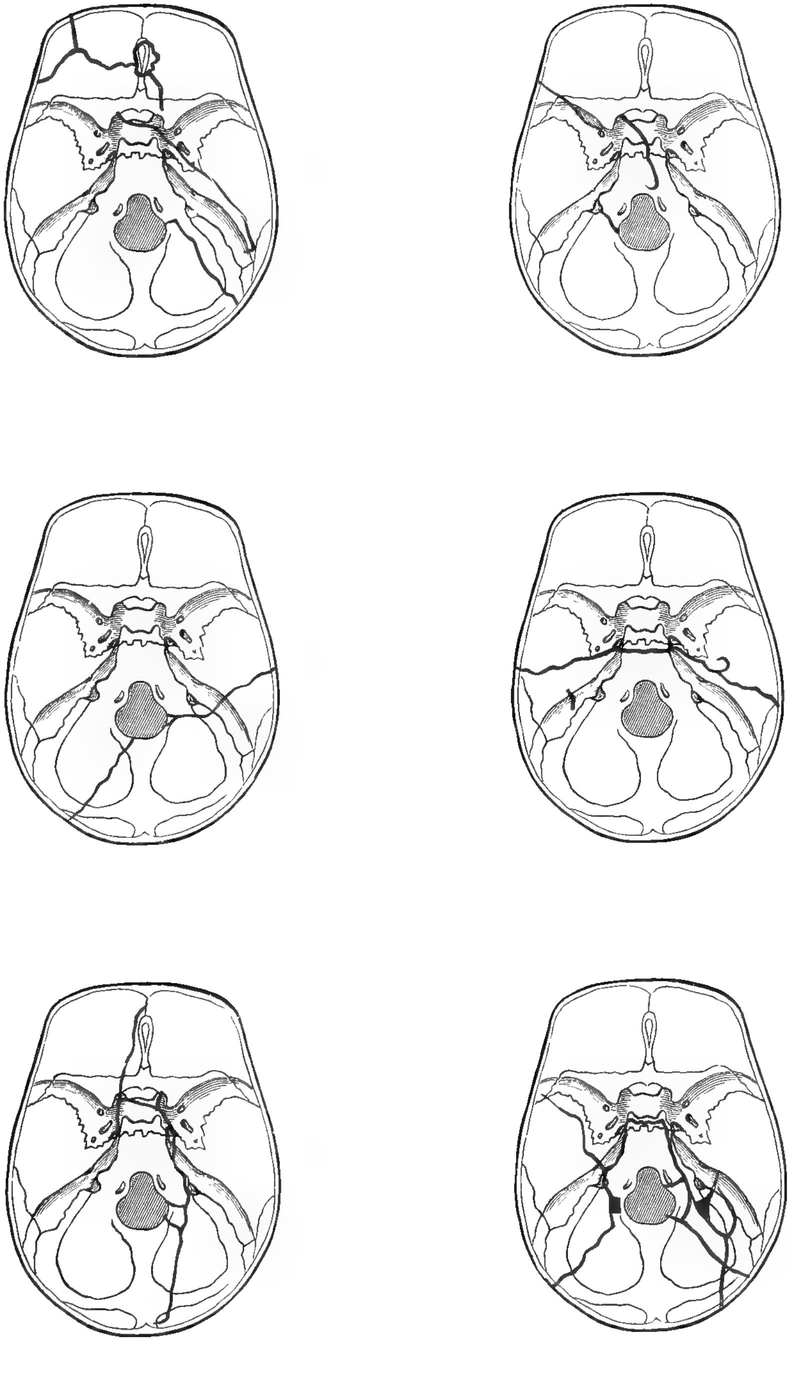
[2] *Experimentelle u. casuist. Studien über Fracturen der Schädelbasis*, Dorpat, Diss. 1881.

[3] *Volkmann's Samml. klin. Vort.*, No. 228, p. 1945; *vide* also Heer, "Ueber Schädelbasis brüche," *Beiträge zur klin. Chirurgie*, ix. 1.

[4] *Internat. Med. Mag.*, May, 1893, p. 322.

[5] See v. Wahl, "Ueber Fracturen d. Schädelbasis," *Volkmann's Samml. klin. Vort.*, 1884, No. 228, p. 1945.

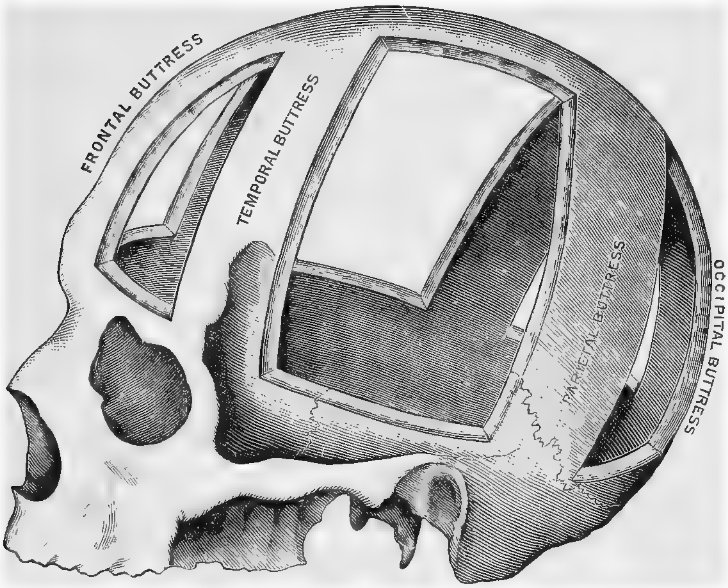
PLATE V.



ILLUSTRATING LINES OF BURSTING FORCE IN BASAL FRACTURES. (Wahl.)

tresses, the former represented by a bridge of bone running from the vertex to the malar process, and then down the great wing of the sphenoid to its base; the latter running through the parietal eminence

FIG. 422.



Preparation of skull, showing the principal arches of strength or buttresses of resistance (Thompson, *l. c.*, after Dolbeau and Félizet).

and mastoid process, and including the posterior part of the petrous bone, the jugular process, and the occipital condyle.[1]

Fractures in the posterior fossa occur, for the most part, through violence applied posteriorly and from below. There is, however, a ring-form of basal fracture which is produced in a rather peculiar way—namely, by the impact of the vertebral column upon the base of the skull, as when an individual falls upon the head. The direction of fissures in this part of the base is, for the most part, either in a direction from the jugular fossa or toward the foramen spinosum, which is the most frequent site for cross-fractures of the petrous portion, or through the base of the pyramid, which is the rarer of the two. The most frequently-broken part of the petrous bone is at that point where it is weakest; this corresponds to the location of the middle ear, where it is hollowed out for so many purposes.

Fractures of the anterior fossa involve the middle portion of the roof of the orbit most often. They may be continued from this point to the optic foramen or the superior orbital fissure. Sometimes the line of fissure divides, one branch extending toward the cribriform plate and the other toward the orbit. If the violence have been great, the fracture often extends beyond the limits of the fossa. A combination of these fractures with that of the malar bone is occasionally met with. This may often extend to the alveolar process of the upper jaw.

[1] See Duplay and Reclus, vol. iii. p. 461.

A study of the mechanism of basal fractures may appear, at first glance, unimportant and unfruitful. This, however, is not the case: a practical importance pertains to studies of this kind which is not usually appreciated. For example, if a patient present symptoms of injury of the petrous bone, and if we find evidences of injury to the lateral region of the skull, then we are in position to make an almost positive diagnosis, because of the experience which has taught how frequently the effect follows the cause, and that blows upon the side of the skull are usually expended in breaking up the base of the middle fossa. So, too, if we find a compound fracture of the frontal region, we may be quite sure that there are coexistent brain-lesions, since experience has shown how frequently in these fractures this obtains. More will be said about the value of this kind of reasoning when discussing injuries of the brain itself.

Besides those fractures of the base which have been before alluded to, where the violence is directly applied to the vertex and its results are seen beneath, it is proper that we devote a few words to that particular form of basal fracture which is due to the impact of the vertebral column against the lateral portions of the occipital bone. In these cases the violence is first applied to the articulating surfaces of this bone. When, for instance, a patient has fallen from a height, striking with the vertex upon the ground, not only is violence applied at the base, but the spinal column, driven by the whole weight of the body proper, strikes against the condyles of the occipital. The violence may be so great as even to drive the condyles into the cranial cavity, although this is an exceedingly rare accident. But it is frequent in these instances that the continuity of the base is disturbed, as well as the contents of the cranium violently contused. A basal fracture usually is more or less regular and symmetrical, extending beyond the condyles, surrounding them and taking a direction toward the jugular foramen, forming sometimes an arch or sometimes a complete ring. With these fractures the petrous bones are usually broken, perhaps through the jugular and carotid foramens, while the fracture may extend into the sella Turcica. Bergmann divides these fractures into two varieties:

First, those where the bone-injury is limited to the base of the skull, while the vertex and the sides escape. Such cases have been described by Chauvel[1] and others;

And, second, into cases where in a similar way the ring-fracture is complicated with fissures radiating toward the vertex in one or more directions.

There is still another variety of basal fractures which is constituted rather by those cases not included above, and which comprises those cases in which the lines of fracture seem absolutely irregular and asymmetrical. We may have, for instance, fracture of the petrous on one side, or the lines of fracture may follow no known rule or standard. There may be added also, although not receiving consideration here, those fractures of the base which are complicated by fractures of the cervical vertebræ, cases of this kind having been reported by Billroth and Waeckerling,[2] and Weber.[3] There is also a case reported by Las-

[1] *Essai sur les Fractures du Crâne*, 1864, p. 17.

[2] *Arch. f. klin. Chir.*, vol. i. p. 473.

[3] *Chir. Erfahr.*, 1859, vol. i. p. 55.

sus, quoted by Fabre,[1] of a patient upon whose occiput a heavy mass fell, and in whom both condyloid processes were broken. As concerns the articulating surfaces of the atlas, they may be driven within the skull, as, it is known, have been the condyles of the lower jaw after violent blows upon the chin. I have had, very recently, to operate upon a little girl who some time ago received a violent blow upon her chin. At the time she bled freely from the nose, mouth, and *both ears*. She came to me with ankylosis of both temporo-maxillary joints, and the condyles were found so firmly ankylosed that I deemed it injudicious not to try to remove them, so divided the necks below. I hold that this was probably an injury to the base of the skull on each side.

There are enough cases on record to establish fracture from either of these sources as characteristic of a variety. Bergmann, for instance, has put on record an injury to the brain itself by the condyle of the jaw, which had thus been made to perforate the skull. The late Frank Hamilton also recorded a case dying six days after injury from a blow on the chin, where similar damage was done at the base of the brain; and similar cases have been reported by Prescott Hewett, Chassaignac, and by Bryant, in each of which the articulating surface of the lower jaw presented within the cavity of the skull. Boyer has reported[2] a peculiar form of this fracture, where the condyle penetrated not the cranial cavity, but the anterior wall of the auditory canal, from which he extracted the bony fragment. Schwartze[3] saw a double fracture of this kind without injury of the glenoid cavity and without rupture of the membrane of the drum. Beach has reported a similar instance.[4] Bleeding of the nose has often been noticed after violent blows or kicks upon the chin. Morvan and Sourier[5] reported an injury of this kind in which with a probe in the external auditory meatus bone-splinters could be detected. Jacobson describes a specimen in St. George's Hospital Museum where the left glenoid fossa is broken and the condyle of the jaw projects into the cavity of the skull. Chassaignac also reports a case where the right condyle was driven into the cavity of the skull; cerebral abscess formed and the man died in six months. When the posterior fossa is broken as above described, the upper end of the vertebral column staves in the foramen magnum or various portions of the occipital and sphenoid bones. The margin of the foramen magnum usually remains intact, because the condyles abut not on the margin, but on the jugular processes of the occipital. This variety has been termed by Marchant[6] "fracture par tassement." Whether the patient receives a blow upon the summit of the head or upon its base, the result is the same, since the skull and the vertebral column come together with crushing force, and the occipital ring is forced into the cavity of the skull, while fissures radiate from it in various directions.

By all means the largest proportion of fractures of the base are mere fissures which are very fine and which close almost instantly after their production—so quickly, in fact, that there is scarcely ever even any

[1] *Dict. de Méd.*, 1840, t. iv. p. 294.
[2] *Journal de Méd.*, 1766.
[3] *Kleb's Path. Anat.*, 1878, p. 43.
[4] *Boston Med. and Surg. Journ.*, 1876, March 2.
[5] *Gaz. des Hôpitaux*, 1869, p. 473.
[6] *Vide* article by Marchant in the *Traité de Chirurgie* of Duplay et Reclus, vol. iii. pp. 458 et seq.

blood included between the broken bony surfaces. Beyond all that has been said before, one must add finally that peculiar or bizarre forms of fracture will be met with or common forms will be produced in most unexpected ways. For instance, it has been more than once recognized after death that there had been a chipping off of one or both anterior clinoid processes or of the posterior processes. Bergmann has reported one case of injury where a little portion of the orbital roof, 3 mm. in diameter, was broken entirely loose and dislocated into the orbit. The aurists have reported cases where similar minute fragments had been dislocated into the auditory meatus; and other curiosities of this kind may be met with by an extensive search through surgical literature.

Prognosis of Basal Fractures.—The significance of fractures at the base of the skull is mainly indicated by the extent of the violence which has produced them. The majority of them are fatal because of contusions of the brain or the large nerve-trunks, or of hemorrhages from other endocranial lesions which are the result of the same violence. Other things being equal, the longer the fissure the greater the danger; particularly is this so when it takes its origin in the vertex. This is because there is greater danger of communication with the external air—*i. e.* by compound features. Even those fractures, however, which are confined to the base are by no means free from this danger of air-infection: the fissures often extend into the air-containing cavities—the ear, the nose, the frontal, ethmoidal, or sphenoidal sinuses—from which infection may sooner or later take place. These fractures, therefore, are better always regarded as compound, even though the open wound may not be visible. If we are to study the prognosis of basal fractures alone, we must necessarily separate all those cases in which the cranial contents are injured. This, however, is out of the question, and the subject of prognosis of these fractures can never be dissociated from that of injuries of the head in general. About the average fracture of the base by itself, however, there is seldom anything which is not capable of repair; in other words, recovery from this injury is often possible. It is a question purely of how badly the brain is hurt or whether septic infection can be prevented. For this purpose, therefore, we may regard statistics as absolutely unreliable, although possessing an interest of their own. In fact, the writer would prefer not to arrange them for reference, since he feels that they would be more misleading than helpful. It is perhaps enough for this purpose to say that recovery often follows undoubted basal fracture, sometimes even of severe type, although in the majority of cases the recovery is not ideal, since there may remain impairment of sight or hearing or some special sense-disturbance, the result of exudate or lesion along the sheaths of special nerves; or there may be impairment of general cerebral function, which is to be explained only as the result of the violent commotion received by the brain at the time of injury. There are, however, numerous museum specimens which show the perfection with which bony repair may occur, and the admirable way in which compensation for defects is afforded or by which weakened parts have been restored to strength. At other times recovery, which has bid fair to be permanent, proves only temporary. Thus, Mauran[1] reports a case in which the necrotic point of the petrous bone lay inside of a large

[1] In Malgaigne's *Traité de l'Anatomie*, 1858, i. 91.

abscess-cavity. In the same author is also quoted a case of Duverney, whose patient died three months after injury: there was a semicircular fissure proceeding from the apices of both petrous bones into the sella Turcica, and there had been apparently no formation of callus whatever. These are exceptional cases, however, and there is ample evidence that bony consolidation of basal fracture is the rule, providing only patients do not die early of their combined injuries.

Suppuration after basal fractures occurs rarely, except in connection with purulent basal meningitis; then, naturally, the brain-symptoms dominate in the clinical picture, and the appearance of a single drop of pus at the ear is of the greatest importance in both diagnosis and prognosis. The conversion of the serous outflow—*i. e.* the cerebro-spinal fluid—into pyoid fluid or into pus is also of the gravest significance, although at least three cases in which this phenomenon was noted have recovered. These were reported respectively by Bênoit, Erhard, and Baguzzi.[1] So Hay[2] reported the case of a sailor who fell from a mast upon the deck and bled from the ear for two days, the blood being followed by serous fluid, and this again by repeated hemorrhages, which ceased for a month, after which began a purulent and putrid discharge: the case finally healed. The reporter was of the opinion that this was all to be explained by the escape of pus from a brain-abscess. Bardeleben has also seen partial necrosis of the petrous bone follow this fracture; it was preceded by hemorrhage from the ear and facial paralysis. Still, necroses following this injury—that is, cases which go on long enough to permit of necrosis, and which do not die of accompanying lesions—are among the greatest rarities in surgery. In the writings of the aurists there are few, if any, such cases reported.

Diagnosis and Treatment of Basal Fractures.—Experience has shown that in the majority of cases not only may fractures of the base be diagnosed, but often even their general direction determined, by a study of the external phenomena. The most significant diagnostic features are—

1. The spread of blood from the point of fracture until it appears at certain points beneath the skin as an ecchymosis;
2. The escape of brain-substance, blood, or serous fluid from the cavities of the skull;
3. The disturbance of function along certain cranial nerves.

So far as the spread of blood is concerned, it appears beneath the skin or the mucous membranes which come either directly or indirectly in contact with the cranial base; for instance, the skin of the lids, the subcutaneous tissue of the eye, the pharyngeal mucous membranes, the region of the mastoid process, and the sides of the neck are the points at which ecchymoses are most often noted. Their appearance permits a conclusion as to the existence of fracture, as also that violence was applied at some point distant from that at which these phenomena appear. Equally characteristic is their late as well as their early appearance. Ecchymoses about the lids have only a limited significance, since it is well known that they are frequently produced by blows which are far from being violent enough to break the skull, the ordinary "black-eye" being common after many relatively trifling injuries. Should, however,

[1] *Vide* Bergmann, p. 223. [2] In the *Am. Med. Journ.*, 1889, vol. xxxvii. p. 354.

ecchymoses about the orbit appear two or three days after injury, they would be much more suggestive, at least in one direction, than those which occur within two or three hours.

Almost all fractures which extend into the orbit will give rise to more or less hemorrhage into this cavity; only the finest fissures bleed imperceptibly. The quantity of the effused blood varies within considerable limits. Hoelder investigated the orbital fat in a number of cases of basal fracture, and found that out of 79 cases where fracture involved the orbital roof, in 69 there was bleeding into the orbital cavity. The involvement of one side or both will give important evidence also as to the limitation of the fracture or its generalized extent: when both orbits and all four lids are involved, one may say positively that the roofs of both orbits are involved in the fracture.

Blood may appear, diagnostically, about the eye in three different ways—either in the lids, in the fat and connective tissue of the orbit, or behind the globe in such a way as to produce exophthalmos. The first is by all means the most common; the third is very rare. Even discoloration of the conjunctiva may occur without basal fracture, it being a part of the phenomena called by the laity "black-eye." Should there be, in connection with these signs about the orbits, ecchymoses posteriorly about the base of the skull, they will be regarded as extremely significant, since then the middle as well as perhaps the posterior fossæ must be involved. It must not be held, however, that all fractures of the base are accompanied by these anterior signs; this is only when the anterior fossa is involved in the way already mentioned.

Exophthalmos is in these cases usually a sign of very great importance, although rarely met with. Prescott Hewett saw it 3 times in 23 cases. Most significant is it in those cases where there has been rupture of the ophthalmic artery. Carron du Villards has reported a fatal case in which this condition was present, where the fracture extended right into the optic foramen; the artery and vein were both torn and the eye was pushed far forward.[1] Vascular rupture in the retrobulbar tissue has been more than once specified as the cause of formation of aneurysm in the orbit, and this usually of the type of diffuse spurious aneurysm.[2] Ecchymoses in the mucous membrane of the pharynx are less often observed, partly because seldom looked for, partly because concealed behind the palate or the nose. They occur most commonly in fractures of the basilar portion of the occipital. In a remarkable case reported by Parmentier[3] there had been fracture of the frontal with extension into the body of the sphenoid and on to the right petrous bone. In this case the blood infiltrated not merely the retropharyngeal tissue, but extended down as far as the second lumbar vertebra.

Extensive ecchymoses about the mastoid process, extending up behind the ear and down some distance on the neck, occur very frequently when the middle or posterior fossæ have been broken. This is not to be interpreted as meaning that the mastoid portion alone is broken, for they are found when the squamosal portion of the temporal is fissured. When the posterior fossæ of the skull are broken, the blood takes its

[1] *Traité des Maladies des Yeux*, vol. i. p. 479.
[2] See Rivington, *Med.-Chir. Trans.*, 1875, vol. lviii. p. 183.
[3] *Union Méd.*, 1862, p. 43.

course between the cervical muscles to appear later underneath the skin, sometimes after several days; the infiltration may also extend well upward upon the skull.

Escape of brain-substance is, of course, diagnostic, but deserves a little attention, for several reasons. When escaping from the external ear it comes most commonly through fissures which involve the upper wall of the ear. It has been shown that minute fractures occur with loosening of fragments of bone; and Holmes has illustrated how easily brain may escape through such traumatic openings. Particularly in the aged there is a rarefaction of bone about the tympanum which permits exactly this accident. The writer remembers a case in which an old woman fell only a short distance, but was picked up unconscious a few moments later, her head lying in a pool of blood. For four or five hours, until her death, there was a steady escape of brain-matter from *each* ear, in spite of the fact that no other evidence of injury could be elicited from without. Schwartze has stated that in fractures of the foot of the stapes, with fissure between the oval and round windows in the tympanum, brain-material has been found in that cavity. A still greater rarity is it when brain-material escapes from the nose, there being but two cases of this kind on record.[1] It does not appear that this phenomenon has ever been seen in the pharynx, although pharyngeal contents have been met with in the cavity of the cranium in one case by Hewett.

Hemorrhages from the cavities and basal canals of the skull occur most often from the ear, nose, and pharynx. The most frequently met with are those from the ear, the petrous bone being so tunnelled by canals which connect with the ear in one way or another that the escape of blood may be permitted, although this blood does not always come from these, but may escape directly from the interior through fissures of the bone. Just back of the tympanum is the transverse sinus; just over it, the middle meningeal artery; and close at hand, the internal carotid. Any of these may be torn at the time of injury, and may furnish the blood which thus escapes, inferences regarding its source and nature being made according to its appearance and the rapidity of its escape. The blood may escape from simple contusion or laceration of the membrane; or from a fracture of the anterior wall, as when the condyloid process of the jaw is driven against it; or from violent separation of the cartilaginous external structures; or from the mastoid cells at the posterior wall of the auditory canal; or, finally, from within, directly through fissures and fractures of the base. One should assure himself in every instance that the blood is really escaping from the ear, and not merely from some perhaps trifling wound of the external soft parts.

The vessels of the membrana tympani and the inner surface of the middle ear are numerous, but small; from them there can be no profuse hemorrhage. When it can be carried out, an examination of the membranes should always be made with the otoscope, by which much may be learned. There are two exceptional instances on record—namely, those of Marjolin and Panas—where there was extensive bleeding from the middle ear, in which autopsy showed only rupture of the membrane without fissure of the bone. When the anterior wall of the auditory

[1] *Compendium de Chir.*, vol. ii. p. 595, and *Bull. de Soc. Anat.*, 1837, p. 228.

canal or the soft parts are fractured and torn, there may be quite free hemorrhage; in fact, the two injuries may be combined. Fractures of the posterior wall of the auditory meatus form the subject of a dissertation by Boullet (Paris, 1878), who reports cases of fracture extending from the vertex into the mastoid process without disturbance or involvement of the petrous bone, and in which there was vigorous bleeding from the ear.[1] It is the longitudinal fissures of the petrous bone which most often give rise to hemorrhages from the ear, and it is these which occur most often after injury to the lateral regions of the skull; while, when the occipital or frontal bones are involved, we most often have to deal with transverse fissures of the petrous. Nor is it by any means every fracture involving the petrous which permits escape of blood from the ear—only those which connect in some way with the auditory passages. When the soft parts about the ear are also lacerated the blood escapes in this way by the easiest and shortest passage. In such a case the membrane of the drum may be uninjured. When the porus acusticus internus of the labyrinth is broken and blood escapes, the bleeding is not likely to be excessive, but continuous, drop by drop, for a long time. It is also difficult to check. When the blood escapes in a stream, it must come either from one of the large sinuses or from the carotid.

It thus appears that not every hemorrhage from the ear may indicate fracture of the skull, but that this is a sign to be considered along with others. The converse of this is also true—that by no means every fracture gives rise to bloody otorrhœa. In a case reported by Voltolini there was fissure of both petrous bones and the middle ears were both filled with blood, which yet did not escape because the membranes were intact. Some idea of the frequency of this sign may be gotten from Hewett's statistics of 32 cases of fracture of the middle fossa, in 15 of which there was significant and distinct hemorrhage from the ear, while in all these cases the autopsy made fracture certain; of the 17 cases which did not bleed, in 12 the point of the petrous was involved.

Even though the middle ear may be seen through the uninjured membrane to be filled with blood, it cannot be positively told from this alone that the bone has been broken, since vascular rupture without fracture is established here even better than in the orbit. Casper has found hæmotympanum without perceptible injury of any of the surrounding parts.

Escape of serous fluid from the ears was mentioned even by Berengarius of Carpi and by Stohlpart van der Wiel; a little later by two Irish surgeons, O'Halloran and Dease;[2] but its actual pathological significance was first made out by Laugier. Since then it has been everywhere accepted as an almost pathognomonic sign. This has now even more value, since comparatively recent anatomical investigations have more clearly defined the subdural and subarachnoid spaces, and have made it clear how fluid may escape from the latter in fractures of the labyrinth or those extending into the middle ear. With these fractures there must of course always be a tear in the dura and in the arachnoid, by which this subarachnoid space is opened.[3] Even by a fracture extend-

[1] See also Marjolin, *Bull. de la Soc. de Chir.*, 1869, p. 3.
[2] Vide Hewett's article in *Holmes' System.*
[3] Vide p. 558, on Anatomical Considerations.

ing into the Fallopian aqueduct along the inner wall of the middle ear there may be communication with the subarachnoid space, there being, according to Rüdinger's investigations, an extension of the arachnoid membrane along the facial nerve to this extent.

The time during which this escape may take place is very variable. It begins almost immediately after the injury in most instances; rarely an interval of twenty-four hours may elapse before it begins to flow. The quantity of fluid thus evacuated is sometimes remarkable. In the ordinary position of the head the fluid escapes upon the injured side in reasonably rapid drops; during violent expulsive efforts, like coughing or sneezing, should they occur, the quantity is increased. In the average the amount in twenty-four hours may be from 150 to 200 cc., occasionally more, and even 700 to 800 cc. have been noted in rare instances. Stohlpart van der Wiel met with one case where the quantity amounted to 50 ounces; and Hilton has observed a case where the fluid escaped so rapidly that the room was filled with watery vapor from it. The amount of fluid seems also influenced by the limitation of the intracranial space as the result of hemorrhage. Jobert de Lamballe saw a large amount of this fluid escape from a stab-wound of the neck which had opened the subarachnoidean space under the atlas.[1] When there is escape of this fluid from the ear, it may be regarded as an almost pathognomonic sign of fracture. However, in very rare instances fluid may escape which is technically not cerebro-spinal fluid, or at least which may be accounted for without rupture, and which is not actually cerebro-spinal fluid. Robert and others of the older French surgeons had the view that this fluid was in effect the liquor Cotunnii, or was pure serum which was pressed out of intracranial blood-clot. There are several observations on record, among others those of Hewett and Gray,[2] which are of interest in this connection. Gray, for instance, saw in a man who had fallen upon the head, first a bloody, then a watery, and finally a clear, serous fluid escape from the ear, which flow lasted altogether for six days, and which during the first two days was so copious that in one hour several ounces could be collected; on the seventh day this fluid became purulent and the patient died. Upon careful dissection and painstaking removal of the dura from the petrous bone, no injury of this membrane could be made out and no fracture of the temporal; the inner ear was apparently normal; there was no abnormal communication between it and the middle ear; but the membrane of the drum was ruptured, and there was muco-purulent fluid in the middle ear, in the mastoid cells, and in the Eustachian tube. Holmes examined a man dying after injury, with escape, first of blood, and later of serum, from the ear; he found the middle and inner ears absolutely uninjured, but in the external ear a laceration produced by a fragment of the lower jaw. Ferri[3] made a section six years after a head-injury which had been followed by copious escape of watery fluid, so that in one hundred and six hours 63 ounces

[1] My colleague, Dr. Parmenter, trephined a young girl in 1890 for epilepsy. During the operation the dura was accidentally wounded. For two succeeding weeks the dressings were changed twice daily, because saturated with cerebro-spinal fluid. As nearly as could be estimated, between six and seven pints thus escaped. Previous to operation the child had an average of from twenty to forty convulsions; she is now strong and active, and has had no epileptic manifestations for four years.

[2] *Trans. Path. Soc. London*, vol. vi. p. 22.

[3] *Gaz. des Hôp.*, 1854, vol. i. p. 5.

were collected. In the temporal there was no sign of fracture, but in the membrane of the drum was a cicatrix of a previous laceration, with evidences of disturbance in the arrangement of the bones of the middle ear. Another similar case by Fedi is also on record.

The supposition that serum may be pressed out of blood-clot and escape in this way is by no means untenable, but appears to actually occur in very rare instances. If this fluid be collected and heated, it will solidify from coagulation. By this sign it may be distinguished from cerebro-spinal fluid. But when this fluid escapes for hours and in a large quantity, this theory of course must be laid aside. Gray has suggested that saliva may pass down the Eustachian tubes into the middle ear and thus find outlet. This is scarcely credible, however, since saliva is never known to escape by this path in any other cases. That serous fluid may be secreted copiously in inflammation of the middle ear is well known: by this means alone a pillow may be kept continuously moist. Finally, it must be acknowledged that, rarely, the labyrinth may be so fissured that its fluid may escape through the middle and external ears. Since Schwalbe's discovery of the relation of the lymph-spaces of the brain, this view seems more tenable; it justifies the supposition that by opening of the lymph-spaces in the labyrinth it is quite possible to have a lymphorrhœa, in consequence, from the ear.

When we attempt to classify cases which are characterized by escape of fluid from the ear we find the following groups:

1. Those in which there is copious and lasting discharge of serous fluid, setting in early after the injury. In these cases one may safely say there is fissure of the petrous bone extending into the subarachnoid space. If the membrane of the drum is untorn, then there must be lesion of the upper wall of the external ear; in the other case there may be transverse fracture extending into the middle and inner ear or the porus acusticus internus.

2. Cases where the fluid does not escape until the second day, and which are usually preceded by lively hemorrhage. Here the diagnosis cannot be made quite so exactly. If, by use of nitric acid or other tests, this fluid can be shown to contain a small amount of albumin—in other words, to be cerebro-spinal—we may still make a diagnosis of basal fracture, probably involving the internal wall of the middle ear, with simultaneous rupture of the membrane of the drum.

3. When but a small quantity of fluid trickles slowly away, either with or without previous hemorrhage, diagnosis is uncertain. These are the cases which are most likely to be followed by recovery.

When after rupture of the petrous bone the membrane of the drum remains intact, but the subarchnoid space has been opened into the middle ear, then the fluid may escape through the Eustachian tube into the pharynx. This accounts for those interesting cases where fluid of this character has escaped from the nose, the first of which on record was related by Robert. This escapes, for the most part, by the nostrils, and may drain off in considerable quantities, the method of escape depending somewhat upon the position of the head. Possibly fluid may be discharged both from the nose and the ear. Fluid may also escape by the nose in fractures of the anterior fossæ of the skull, communication taking place through the ethmoid cells and the cribriform plate. Lebled relates

that on section of one such case he found the location of the fracture and of the dural laceration in the sella Turcica extending toward the cribriform plate, from which the fluid could percolate into the nose. A few cases of this kind are on record.

Paralyses of particular groups of cranial nerves or of individual nerves are often produced by fractures of the base, for the most part when the line of fracture involves the foramina of exit. In these cases either the nerve is directly lacerated or a loose fragment of bone has inflicted some injury upon it, dividing, pressing, or contusing it. The result of such injury is the immediate loss of its function and the paralysis of the parts supplied by it. But these paralyses may also result without the above conditions, since it is now well known that there may be either involvement of the origin of the nerve in the brain or an ascending neuritis by which its function is slowly compromised and finally lost. After injuries of the former variety it is most commonly the seventh and eighth pairs which are involved.

Such is the violence accompanying or causing the injuries so far described that, as a matter of fact, we often have not merely injuries of nerves and vessels, but serious lesions of the brain itself—contusions, lacerations of its substance, and damage produced by hemorrhage. Aside from those already alluded to, we may have those disastrous lesions of the brain which may be produced by the driving in of fragments of the base or penetration by the condyles of the jaw, etc. In other instances the walls of the orbit, particularly the roof, may be driven directly into the brain. We have already spoken of one instance in which the condyloid process of the occipital was broken loose, and so displaced as to make fatal pressure upon the medulla, the patient dying in seven hours. All these injuries of the brain are produced practically by the same mechanism as that which fractures the bone, and simultaneously with it. The only exceptions to these statements are such rare instances as that related by Charles Bell, of a man who was brought into the hospital suffering from severe head-injury. Two physicians at once attended him: one began to make venesection, the other to shave the head. The patient suddenly stopped breathing and died.[1] On section it was found that there was a fracture of the base extending into the foramen magnum in such a way that a loose portion of bone was suddenly dislocated by that movement of the head which was necessitated in the process of shaving the scalp and preparing him for examination. Another case of this kind was a patient admitted into the Middlesex Hospital after severe contusion of the head. He recovered apparently, and prepared finally to leave the hospital. On the day selected for his departure he had been around taking his farewells; he turned around quickly to speak to somebody and fell dead. Upon investigation it was found that there was a similar fracture in his case; as he turned his head the loose piece of bone was suddenly displaced and perforated the cord.

In addition to the symptoms of basal fracture mentioned above we may mention those which are occasionally met with, and which have been by many attributed to lesions of the semicircular canals. It was Ménière who classified a peculiar group of symptoms according to results of certain physiological experiments made by Flourens, and who de-

[1] An exactly similar experience has recently occurred to the writer.

scribed the peculiar vertigo of labyrinthine disease. It does not follow, however, that all patients who have vertigo, or even more distinct ear-symptoms after head-injury, have sustained lesion of the labyrinth, but it is a legitimate explanation for a limited number of these cases. Unfortunately, the findings on autopsy have not always borne out a diagnosis made solely on these clinical manifestations, since they may be explained by hemorrhages or by inflammatory sequelæ without fracture, as well as by minor central lesions of certain areas of the brain. It is, however, positive that certain cases—for instance, that reported by Schwartze of accidental injury of the external parts with opening of the Fallopian canal, in which disturbance of muscle-sense and vertigo occurred with every movement of the head—are unaccompanied by central lesions.

Another exceedingly rare consequence of fracture is that produced by communication between the cavities of the petrous portion and the mastoid cells as result of fracture. Chevance[1] observed a thirty-year-old patient who had fallen upon the feet, and who later developed a tumor which extended from the left ear well around posteriorly and anteriorly on to the forehead; the skin was distended without redness, and upon pressure there was a peculiar hissing sound, which made it certain that there had been infiltration of air through the mastoid cells into the subcutaneous connective tissue. As spoken of elsewhere (p. 501), this is well known as the explanation of certain pneumatoceles which occur in this region as the result of rarefaction of the bones; but in Chevance's case when the air was thus expelled the patient became dizzy, and not only heard badly, but complained of unbearable pain in the head, which disappeared as the tumor gradually filled with air again.

Less rare as a sign of basal fracture is emphysema of the overlying soft parts, which is perhaps more commonly observed about the orbits and the lids than elsewhere. Ménière describes a case of fracture into the orbit and through the ethmoid into the anterior fossæ: during life this patient had an emphysematous tumor of the frontal region. The same writer has described also another case, in which recovery followed, which he would explain in the same way. The Germans have a peculiar expression for the eye which is somewhat displaced in the orbit by emphysema of the orbital cellular tissue. It is known as "glotzauge," or "gooseberry eye." Desmarres[2] relates that one patient who had been thus injured could, by blowing the nose violently, protrude the left eye at least a centimetre; by this motion it was also so far displaced that diplopia was present. After a short time, if not again disturbed, the eye receded into its proper position. Grüning of New York has reported two cases of emphysema of the orbit following basal fracture. In one, after a blow of the fist, and in the other, after a fall upon the forehead, there quickly developed elastic tumors, which gave the characteristic sound under the fingers. In one case a fracture of the ethmoid plate was diagnosed. Both cases developed rather quickly after sneezing.

Treatment.—So far as the treatment of basal fractures is concerned, it differs but little from that already mentioned for fractures of the vertex. The principal addition to be made refers mainly to the endeavors necessary to preserve an antiseptic, or, if possible, an aseptic, condition of those

[1] *Union Méd.*, 1863, p. 98.

[2] *Anal. d'Oculistique*, vol. xiv. p. 97.

cavities into which or from which cerebro-spinal fluid is escaping. It is much easier to make efforts in this direction in the ear than in the nose. An ideal aseptic condition in either place is impracticable, but the nearest approach possible should be sought for and maintained. When the middle ear can be seen to be full of blood, it will be perfectly justifiable and proper to divide the membrane, to wash out the clot, and to maintain an antiseptic condition of the parts. This is true even of some instances when there has been rupture of small vessels of the tympanum as the result of whooping cough in children, where suitable division and irrigation will do less harm than undisturbed and unevacuated clot. When we have to deal with the suppurative condition of the ear, very frequent, perhaps even continuous, irrigation should be maintained for at least some days. Should bony fragments appear in the meatus or elsewhere, they should be carefully dislodged and removed. Only by constant watchfulness in the direction of surgical cleanliness, in addition to the general canons of treatment, can any insurance against purulent meningitis be obtained. The writer has had occasion to imitate the method of applying leeches about the base of the skull first impressed upon him by the practice of Mr. Lawson of Middlesex Hospital—a practice often followed by most gratifying results.

Direct Fractures of the Base of the Skull.

Under this expression we refer to the instantaneous effect of applied violence at or near the point of its application. From two directions in particular—namely, from the orbits and from the nose—is it most commonly possible to have accidents of this kind. These refer not only to gunshot fractures, but to rare accidents such as shall find mention below. The orbital roof itself is a thin plate of bone which is incapable of withstanding much violence. When the exposed orbital margin is seriously injured there is usually a continuation of fracture into the roof of the orbit, and often into the horizontal plate on to the ethmoid. When by a compound fracture the supraorbital margin of bone is exposed, it is not infrequently possible with the finger or the probe to follow the line of fracture in the direction above indicated. Such fractures have been followed even into the very base of the skull, and such injuries may result in necrosis, which complicates the process of wound-healing. Brain-symptoms do not always appear in these cases. That orbital fractures by themselves admit of a favorable prognosis, as a rule, is shown by Berlin's statistics, who found 17 recoveries in 20 cases.[1] Berlin also found 52 cases of direct fracture of the orbital roof without participation of the orbital margin; these were, for the most part, gunshot wounds. By various implements, however, such fractures may be produced, as, by canes, ramrods, drumsticks, rapiers, forks, splinters of wood, needles, etc. These objects often penetrate the brain. Most of these perforations occur in the neighborhood of the superior orbital fissure, the objects being deflected to this point by the overlying bone. Thus, either the anterior lobes of the brain are injured or the lateral ventricles may be perforated. In other instances when the optic foramen is entered the optic nerve is injured or divided. In direct fracture

[1] See *Graefe and Saemisch's Handbuch.*

of the orbital roof there are frequently radiating fissures extending from the opening made by the perforation at the time. These may radiate in all directions. The foreign bodies enter, for the most part, through the upper or lower lids—sometimes between them in such a way that the lids are not injured. Van Diest relates the instance of a soldier injured in a scuffle, who died in coma with convulsions. A comrade had pushed a fife into his face. Section showed that the instrument had entered the left orbit, had broken away the wall extensively, and had injured the brain. The appearances of the external wound do not indicate accurately either the depth of perforation or the size of the foreign body. In several instances it has happened that a cane or umbrella point, being pushed into the orbit and perforating the brain, has in the effort of withdrawal lost its metal tip, which has been left remaining in the brain. W. Cooper, for instance, reports[1] the case of an officer wounded with an umbrella. Some days later the patient returned home on foot, was seized with convulsions, followed by coma and rapid death. The copper tip of the umbrella was found in the anterior lobe of the brain. In 18 quickly-fatal injuries of this general character, collected by Berlin, there were found lesion of the brain in 11 cases and serious intracranial hemorrhage in 6. Brain-abscess is the very common later result, providing cases live long enough to develop it. In Berlin's 18 cases just referred to this was the cause of death in 15, while meningitis was the cause in 2 cases. It is both interesting and important to know that these brain-abscesses are all found in the immediate neighborhood of the original injury. In 6 of these cases splinters of bone and foreign bodies were found within the brain. Of 11 patients recovering from this character of injury, 3 remained hemiplegic, 1 imbecile, and 1 suffered constantly from headache.

The following case of penetrating wound of the anterior fossa through the orbit was reported by Lusk of Warsaw, N. Y.:[2]

In a runaway accident a lady was thrown from her carriage against a lamp-post, driving a piece of gas-pipe, with a blunt end five-eighths inch in diameter, into the forehead to the depth of one-quarter of an inch. Her swaying body remained suspended in this position until removed by two strong men. Along with a ragged scalp-wound and internal injury there was also laceration below the inner angle of the orbit, extending along the upper margin of the malar bone, and forming a square flap which was torn out from the side of the face. This flap contained part of the contents of the orbit. The eyeball was intact, but completely separated from its attachments. Beginning at the external angle along the supraorbital line to near the internal angle, and thence downward to the lachrymal groove, there was not a single piece of bone. Hemorrhage was quite profuse, but was easily controlled. The optic nerve and ophthalmic artery were completely divided, along with all the nerve-supply to the structures within the orbit. The dura mater sustained a slight rupture, nearly admitting the end of the finger, too deep in to suture. Patient was treated symptomatically. Recovery as complete as was possible, her sense of smell being slightly perverted and hearing in left ear materially diminished.

[1] *Annales d'Oculistique*, xxxiii. 216.
[2] *International Journal of Surgery*, Dec., 1893, p. 346.

Diagnosis of fractures of the orbital roof must be made in large measure by the exact history of the case. The fact must not be forgotten that minor violence is sufficient to break the thin plate of bone, and that serious brain-symptoms, developing after such an injury, are of themselves strong evidence in favor of its penetrating character. It is often seen that the wound is closed, either by clot or by a prolapsed mass of orbital fat. In every case the finger or the probe should be used for an examination, in order to exclude the possibility of fracture if possible. The very motility of the orbital contents makes it easily possible that that which was originally a straight canal—*i. e.* the wound of entrance—shall be more or less closed or contorted by the time of examination. Selwyn has reported one instance in which after such an injury there was external escape of brain-substance. Brain-symptoms do not necessarily immediately follow the injury, but may be later manifestations, and they are not necessarily nor always fatal.

The following case of penetrating wound of the brain through left orbit, with hemiplegia, followed by removal of clots from the base and recovery, by Laplace,[1] will show what can be done in some cases of undoubted fracture: A boy fell on a broken fencing-foil, the steel penetrating the left orbit between the inferior margin and the eyeball. A few moments later the child was found unconscious, with the steel still in the wound. Later the child presented right hemiplegia, left facial paralysis, and complete aphonia. Respirations, 30; pulse, 140; temperature, 104.5°; comatose. After exploring the orbit without detecting spiculæ or detached bone, it was inferred that the steel had passed through the sphenoidal fissure, and it was determined to wait. Ten days later the patient was in profound collapse, during intervals of which there was great restlessness; no improvement in general condition. Holding that the symptoms were due to clot at the base of the brain, the trephine was resorted to for relief of tension. From the direction taken by the instrument, it was evident that the middle fossa had been penetrated and that the clot must be sought for there. In order to break the suspected clot, a miniature egg-beater of platinum wire was improvised, which could be passed between the dura and the skull and twisted about. This was done, and a whole teaspoonful of old clotted blood was removed piecemeal. While dragging more out there was considerable hemorrhage from the result of removal of a clot that occluded the injured cavernous sinus. Wound was plugged with gauze and graduated compression applied. Patient reacted well, and steadily improved after operation. Some months later he was bright and cheerful, had recovered the use of both legs, and could take a few steps without support.

The **treatment** of these cases hinges in large measure upon removal of the foreign body and prevention of hemorrhage. Should there be anything in the account of the injury obtained to justify it, it would be perfectly proper to enlarge the wound to any desirable extent, to remove the bone, or even to trephine the frontal bone above the orbit, and after opening the dura make serious exploration of the anterior lobe of the brain. Indeed, it is quite easy to imagine a case of this kind where extensive osteoplastic resection of the frontal bone would be called for. At all events, rigid disinfection of the entire wound must be made,

[1] *International Med. Mag.*, 1892.

after which drainage or antiseptic occlusion may be resorted to, as shall seem most indicated. The danger of purulent meningitis or of brain-abscess is, of course, enhanced by any infectious process going on within the orbit; consequently, it would probably be wiser to resort to occlusion only very rarely.

Another method by which the anterior fossa of the skull may be directly broken is by injuries through the nostrils. These of course are rare, but by no means unknown. Anderson[1] reports the history of a musician entering the hospital with severe brain-symptoms and dying of the same, who showed externally only a trifling wound of one nostril. On autopsy it was found that the point of a walking-stick had perforated through this nostril into the anterior fossa, and that the brass tip of the same had been dislodged and lay upon the sella Turcica. A similar case was reported during our Civil War: a nurse received a sabre-wound in the right nostril, and soon after became unconscious; the hemorrhage was supposed to come from the nostrils alone, but he died of coma and compression-symptoms, and on autopsy the convexity of the right hemisphere was found enveloped in blood. This had extended widely along the base, and considerable damage had been done within the cranial cavity.

As the orbital margin may be broken off, so may also the mastoid process. In Casper-Liman's *Handbuch* is reported a case in which, on section, along with five other fractures of the skull it was found that the mastoid process had been completely loosened at its base. Boullet[2] has described its separation by a kick from a horse; and Dupuytren[3] reports a case where it was broken off by a bullet. Boullet showed by experiments on cadavers that it was experimentally possible to have a complete separation of this process at its base.

Gunshot fractures of these parts of the skull are referred to in Volume I. of this work.

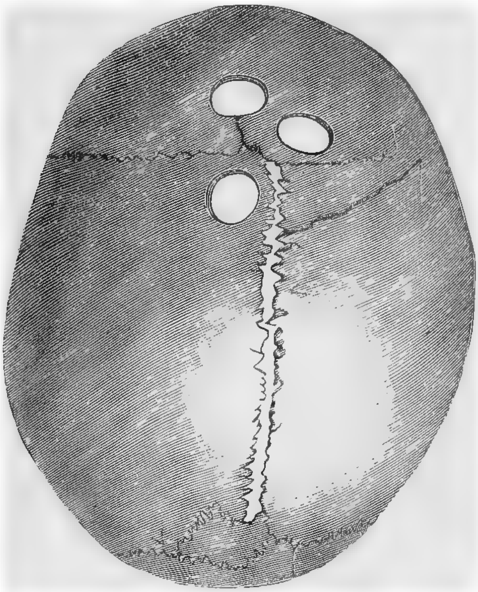
Separation of Sutures—Diastases.

Interesting as is the study of the mechanism by which the bones of the skull are bound together, and complicated and perfect as seems to be the union along most of the sutures, it is nevertheless possible to have separation of the same as the result of violence, although this alone without simultaneous fracture at some other point is a rarity, Hewett only having observed it once—at the squamo-parietal suture, where the temporal bone was pushed outward on the parietal. Holmes in one instance found on autopsy a separation of the entire coronary suture, and no other bone-lesion: the frontal bone remained connected with the parietals only by periosteum; all the other sutures were undisturbed. Ordinarily, diastasis of sutures is an accompaniment of simultaneous and usually extensive fracture extending into the base. Under these circumstances it is usually recorded as involving only a portion of some particular suture. Of 68 cases studied by Hewett, in 14 there was more or less separation of suture, and of these 14 cases the coronary suture was 7 times involved, the lambdoid 6 times. Much more rare is the

[1] In the *Dublin Quarterly Journal*, 1851, p. 347.
[2] *Thèse de Paris*, 1878.
[3] *Leçons orales*, p. 158.

complete separation of some particular cranial bone by loosening of all its sutures, as, for instance, of the frontal bone, as has been noted by Hewett, or of the parietal bone, as recorded by Eichheimer. Caradeck[1] once observed the complete separation of a Wormian bone from the posterior end of the sagittal suture, it being completely displaced inside the

FIG. 423.



Diastasis of median suture (Bruns).

cranial cavity. The fractures which are most often accompanied by diastases of sutures are the gunshot fractures, most of which are perforating, and many of which are thus complicated. Inasmuch as the sutures of the young are less firmly closed than those of the old, we naturally find this injury more commonly in younger individuals.

Evidences of recovery from diastases have been seldom met with: it has been most often found that fibrous tissue has taken the place of osseous in closing the defect, although ossification of this tissue may later occur. A complete reproduction of the original arrangement has been seen, perhaps, only twice. Larrey once noted separation of the left half of the coronary suture in a soldier who died six months later of fever; in this instance he found an almost complete imitation of the original denticular arrangement. Ollier[2] has determined the possibility of this same perfect repair in animals. Gudden has also studied the subject experimentally, and has come to the same conclusions.

Diagnosis of these injuries is usually only possible as they are exposed to sight.

The **treatment** is in nowise different from that of other fractures or similar injuries.

[1] *Gaz. méd. de Paris*, 1871, No. 4.
[2] *Traité de la Régén. des Os.*

Injuries of the Frontal Sinuses.

At the lower part of the mid-frontal region the diploë is expanded into air-containing cells known as the frontal sinuses. The separation of the outer and inner tables varies very much in individuals, and is not even symmetrical in any single skull. The location of these cavities between the bony tables is the principal reason why fractures of the external table in this locality are of much less significance than elsewhere, and may be met with alone without lesions of the inner table. By virtue of the connection of these sinuses with the nose it often happens that we have to do with emphysema after injuries in this region, the air being blown directly underneath the periosteum or the subcutaneous tissue. Desprès[1] has reported one remarkable instance of a sixty-year-old man who fell upon his forehead, and later suffered from an almost universal subcutaneous emphysema: crepitation was felt not only about the face, head, and neck, but also over the thorax, the abdomen, the lumbar region, down the arms, and even in the palms of the hands. In three days his condition was improved, and in sixteen days he had recovered. Emphysema constitutes the principal diagnostic point under these circumstances unless there is palpable lesion. When the patient with closed nose and mouth can blow air underneath the frontal tissues, there can be no other explanation for this sign except the injury under consideration. Those injuries which permit this emphysema are almost always followed by nose-bleed, or at least blood will escape into the pharynx and be swallowed. Morel Lavallée relates that a boy who fell upon the forehead and suffered from emphysema in this region not only vomited blood, but expectorated it.

Wounds of the frontal region which open this sinus are of importance for two reasons: On the one hand, the Schneiderian membrane can, by complications thus brought about, entail great danger to life; or by the union of the wound-borders with those of the skin at the seat of the wound they may lead to permanent fistulæ, or at least those which it would be difficult to heal. When from injuries of this kind the inner table is also injured, we must redouble our precautions in order to avoid brain-complications. In one case, reported by Evans,[2] the external wall of the sinus was driven in and penetrated the internal wall, and in other instances the roof of the orbit had been injured in a similar way. By wounds which may be thus made in the ethmoid there may be felt a stream of air as the patients breathe or cough, but this phenomenon is observed only in those cases where there has been separation of the soft parts. In some of these instances, as Boyer has described, there may be seen a rhythmical rise and fall of the exposed membrane with each act of respiration. Rizet has even seen a hernial protrusion of this kind.[3] Such prolapse must not be mistaken for hernia cerebri. Pus which escapes from the frontal sinuses is always thin and usually has more or less odor. Long continuation of suppuration means the formation of sequestra. Sometimes the pus escapes by the nose as well as externally.

[1] *Gaz. des Hôpitaux*, 1872, No. 54. [2] *St. Bart. Hos. Rep.*, 1868, vol. iii. p. 243.

[3] *Vide* also Körber, "Gerichtsärztliche Studien über Schädelfracturen," *Deutsche Zeitschrift f. Chirurgie*, xxix. 545.

Injuries to the Brain and its Adnexa.

GENERAL TRAUMATIC DISTURBANCES OF THE ENDOCRANIAL CONTENTS.

Comparatively few years have elapsed since Flourens and Vulpian taught that all parts of the brain functionate alike, and are, as it were, interchangeable. The change from that teaching to the accepted and demonstrated doctrines of to-day, that a localized pressure on the central nervous system acts as does a localized injury and gives rise to disturbances of certain functions or certain parts of the body by which, for the most part, the lesions can be recognized, is most abrupt and most complete. Veyssière's needle experiment and Nothnagel's chromic-acid injections both alike taught the separation of the sensory and the motor portions of the brain, as we know them to be separate in the cord; while the studies made by Gudden concerning secondary atrophies in the nervous system which follow injury to limited areas of the brain have shed, in their time, the most important light upon this previously obscure subject. The result of these earlier efforts, as well as the combined labors of men whose names are still in the mouths of every student of experimental physiology—men, for instance, such as Hitzig, Ferrier, Horsley, Franck, and many others—has been to bring about a well-established and generally accepted teaching, upon which the labors of all surgeons who work in this part of the body are based.

And, first of all, we have been taught to distinguish between lesions which involve a certain limited part of the brain itself and those which compromise the entire encephalon with its membranes. In other words, we have to distinguish between—

1. General traumatic disturbances of the endocranium; and

2. Localized injuries to the brain or to particular vessels and nerves entering into its composition.

So far, then, as concerns the first—the general lesions of the brain—it is possible that the circulation either of blood or lymph within the cranial cavity may be so affected by injury that these most sensitive nerve-masses are influenced in their nourishment and have their function thereby perverted or destroyed. Or, again, it is further possible, without any perceptible disturbance of the circulation, to so influence the entire central nervous system that the whole now acts as a part does in the above instance—in other words, that the entire activity and the total functions of the brain are mildly or seriously perverted. In the first case it is brought about that the condition is one practically of the presence of a foreign body in the widest acceptation of the term, which determines the disturbance of function, since the now injured and more or less useless part of the brain acts in this way, disturbs the circulation, and takes up perhaps valuable space. Or, this foreign body may consist entirely of blood-clot, which is pressing upon a small or large area of the brain and thus compromising its usefulness. In the second case the condition is one which has been so often spoken of in time past as "concussion of the brain," upon which, both previously and now, there still exist wide differences of opinion.

Before, however, going into the details of this part of the subject

there must be a few words devoted to the anatomical and physiological aspects of this question. The relations of individual portions to each other and to general pathological processes, to acute as well as to chronic ones, in other parts of the body, as well as to those within the cranium, can never be lost sight of. It was Magendie who first taught us the importance of that particular component of the endocranium which is so variable—namely, the cerebro-spinal fluid. It is this which brings about the most rapid alternations of pressure, and consequently the most rapid variations of endocranial space, its influence being even greater than that of the venous current. Donders had fitted an air-tight glass window in the skull, and had carefully studied the influence of venous pressure, but it remained for Magendie to teach us the importance of the cerebro-spinal fluid. The principal importance of this fluid in this connection obtains in that there is an easy path between the inelastic cranial cavity and the spinal canal, whose walls are more capable of accommodating an increase of fluid than is the case above. In other words, when brain-pressure is increased the spinal canal serves as a reservoir for the fluid which is pressed out of the cranium, so that there is more accommodation of pressure and more equilibrium between the two than would otherwise obtain. By the modern method of injection Schwalbe was, and afterward Key and Retzius were, able to prove that the subdural space was extended along the optic nerves, through the olfactory even down into the nasal mucosa, and along the auditory even into the perilymph spaces and the bony labyrinth. By the same kind of investigation they were able to prove that the subdural and subarachnoid spaces do not connect at any point, either in the brain or down the cord; in other words, the subarachnoidean space is an absolutely closed sac. This has an important pathological as well as physiological bearing.

Before the investigations of Althann and Key it was supposed that the cerebro-spinal fluid was enclosed in numerous completely separated compartments. So long as this view was held a free communication between the subarachnoidean space and the spinal cavity naturally seemed impossible. It has been, therefore, a distinct advance to do away with this error, and show how easily the fluid may pass from one cavity to the other, as well as its free admission to all the endocerebral folds, ventricles, and spaces. In other words, from the convexity of the brain down to the lower end of the spinal canal there is free communication, as well as with the ventricles, and even with the perivascular sheaths, which are in effect nothing else than modified subarachnoid spaces. These facts were determined by these investigators by the injection of blue fluid, which was thrown into the spinal canal and was seen to permeate into all the spaces in the brain above mentioned. The connection of the subarachnoid space with the lateral ventricles by an opening in the lower wall of the fourth ventricle just where the choroid plexus escapes was first made clear by Magendie, whose name was given to the foramen which he discovered. That this opening is no artefact has been now for many years clearly demonstrated.

In spite of the constant limitations about the brain, its volume is altered in the most rapid way: with every systole of the heart it expands, with every diastole contracts. Its size is also modified by the motions of respiration. Thus, the alterations peculiar to the brain are of two

varieties—those connected with the pulse, and those connected with breathing, it being with every inspiration that its volume is decreased. While these are matters that most interest the physiologist, they have their bearings in the consideration of certain surgical cases. With extensive elevation of blood-pressure inside the skull there is increased escape of lymph into the lymphatic vessels.

We are brought face to face here with a really interesting phenomenon—namely, the escape of cerebro-spinal fluid from an inexpansible cranial cavity into the more or less elastic spinal cavity, by virtue of which a certain degree of protection is afforded from injury. *A priori*, distention of the latter cavity is scarcely credible; but when we remember that the spinal column is composed of articulated segments between which, and inside of which, there is much soft tissue with many openings, it seems much less difficult of appreciation. Upon opening the obturator membrane between the atlas and the axis or the atlas and the skull it is very easy to demonstrate a dilatation with each systole. The elasticity of this membrane is striking and indicative, and shows what may occur with the membranous and ligamentous tissues between the other members of the spinal column. In the normal state the dura never completely fills the entire spinal canal, but there is always space between it and the bone, which is filled ordinarily with soft fat, which may be forced out into the intervertebral foramina. The dural prolongations which accompany the spinal nerves, and which scarcely more than half fill the foramina, are also capable of dilatation. As the result, then, of many experiments, we may conclude with positiveness that the outflow of this fluid from the cranial cavity constitutes the means by which additional space is afforded within the cranium, or for whatever may induce pressure upon the brain; and the laws of hydrostatics are here maintained, so that the pressure of this fluid is the register of endocranial pressure, although this may not always be easy of demonstration.

Of the three component parts of the endocranial contents, we see that the cerebro-spinal fluid and the blood may be so altered in amount that when one is present in excess the other is deficient, and that the equilibrium of pressure may be maintained at the expense of one or of the other to at least a certain degree. These two components, so alterable in their amount, are those which, except in cases of actual depression of bone, constitute the compressing forces as against the practically unalterable nerve-tissue itself. These phenomena, however, are not always constant, as may be learned from Pagenstecher's experiments, which show that the intraspinal tension varies with various individuals.

CONCUSSION AND CONTUSION OF THE BRAIN.

The word "concussion" we inherit from the oldest masters of our art, since the expression was used by Hippocrates, Galen, and Celsus, but in a much broader sense than now. Its more modern significance was given to it first by Boirel, since he made it apply to a group of symptoms, the result of injuries to the head not due to fracture nor to perceptible laceration of vessels, temporary and of variable intensity. It was Littre who first studied the matter *post-mortem*. In 1705 a young criminal who was to be broken upon the wheel anticipated his

execution by running violently against the wall of his cell, striking upon his head; he fell and died at once as the result of his injury. Littre was astonished when, on autopsy, he found the skull itself intact, and upon opening it could find neither hemorrhage nor any other perceptible lesion, save that the brain-substance seemed to him somewhat firmer and that it seemed to have receded to a slight extent from its bony walls. He then first connected these apparently trifling alterations of the brain-tissue with the major results of such injuries to the skull. After him undue importance was ascribed to this recession of the brain-tissue. It was the subsequent researches upon vibration within the bone which helped to clear up the subject. Petit best succeeded in formulating the knowledge of his day, which does not vary much from the tenets by some recently held. It was to the effect that as the result of violence vibrations were produced, which were continued to the brain-mass and caused its disturbance: the prevailing opinion was that by these oscillations the brain-substance was in its fibres and cells dynamically affected and paralyzed without molecular changes. To this view surgeons like Boyer, Abernethy, and Astley Cooper lent themselves completely.

Later, men took up more carefully the study of the character of the injury from which the central nervous system thus suffered. Was it the impact of the brain, violent but momentary, which thus disturbed its function by minute lacerations or molecular changes, or did it come about in some other way that the brain-functions were disturbed without the slightest perceptible injury? In clearing up this matter there is this to be said which is extremely important: that the post-mortem records, upon which the opinion can be based that in these instances there is no perceptible alteration, are so incompletely reported and so essentially rare—in other words, so unsatisfactory—that it can be almost positively maintained that such a thing as this is impossible. On the other hand, as against the very small number of autopsies which can be held to sustain this view, that a genuine pure form of concussion may be fatal, there are a great many observations which tend to make such views quite untenable. The trouble in time past has been largely that very slight injuries were regarded as equivalent to no injury of the brain-substance; but physiologists have taught us that the most minute injuries of certain parts of the complicated brain-structure are enough not only to disturb function, but to destroy function and even life. It may probably, then, still be maintained with accuracy that the so-called fatal cases of concussion are in effect cases at least of contusion.

From a clinical standpoint there is even more to this subject. In case of any injury of the brain-substance which does not prove fatal we have a right to expect that after the lapse of a certain time there is more or less repair. The disturbances thus produced require at least a certain time for repair before there can be complete healing or restitution of function; but there are cases of head-injury which, apparently most severe at the time, quickly recover. If one, for instance, receives a severe blow upon the head and loses consciousness, becoming cold and pale, with altered pulse, and lying for a few hours in apparently a dangerous condition, and then quickly recovering his normal condition, we may infer that there must have been some serious disturbance of tissue to produce such

a result; still more so when the case presents deep prostration with temporary paralyses and disturbance of peripheral nerves. Of course, one naturally thinks of the conditions brought about purely by emotion, such as fright, joy, and so on, and perhaps finally takes refuge under that very vague but comforting expression of "traumatic neurosis," or, when very temporary, of "traumatic narcosis." Pirogoff in his experiments with animals endeavored to formulate some definite symptoms from those cases where on autopsy there could be found no intracranial hemorrhage nor material lesion, but failed in the attempt. Others have experimented by blows upon the head, which was rested upon a cushion. Beck, for instance, in twenty-six experiments only succeeded once in killing an animal without producing perceptible lesions and extravasations in the brain; and Alquié[1] did not succeed once in many attempts. These experiments, therefore, lead us to the conclusion that violent blows which produce anything like fatal injuries do it in consequence of material lesions within the brain, and not as the result of a fatal form of pure concussion.[2]

The theory of communicated cerebral vibrations, advanced by Petit, accepted by Gama, held ground almost unchallenged for a long time, and then came the time when experiments were made to actually determine under what conditions vibrations could be thus transmitted. In the mean time many autopsies were made, in which there were found minute extravasations within the cerebral substance, which were called "compression apoplexies." These led to a modification of previous views, and Velpeau and his followers began to distinguish commotion, so called, as the first degree of contusion. Then Pirogoff, Fano, and Beck began to experiment with animals. Most of these observers found that it was impossible to so contuse or injure the head as to produce death without finding notable lesions at the autopsy; and the views of surgeons concerning the process of fatal commotion without perceptible lesions began to change. Then came the interesting experiments of Aran in 1844, of Félizet in 1873, of Baum in 1876, and of Messerer in 1884. In 1871,

[1] *Gaz. méd. de Paris*, 1865, No. 15.

[2] It was, perhaps, Boirel who first, in 1677, divided true cerebral commotion from other brain-troubles. In 1766, Valsalva first established the relation between cerebral lesions and the symptoms which depend upon them. He declared that the paralyses which follow certain injuries to the head had their origin in the brain and on the side opposite to the paralysis. In 1705, Littre gave a new direction to the ideas then held concerning cerebral commotion, as already mentioned. The study of injuries to the head made slow progress until the Academy of Surgery of Paris proposed it as a subject for a prize in 1760 to establish a theory of contrecoup and to determine its consequences. This topic provoked a large number of publications and memoirs, of which perhaps the most important was that of Grima, published in 1766, with another in 1778. Petit introduced a new interpretation of the facts observed in cerebral commotion in 1774, which he would explain by the transmission to the brain of vibrations communicated by its osseous envelope and the consequent suspension of its functions. He did more than this, moreover. He systematized the symptomatology of various cerebral lesions, such as encephalitis, hemorrhages, etc. Percival Pott had previously described separations of dura and formations of clot. Petit insisted particularly upon the fact that commotion follows the injury immediately, whereas the symptoms of hemorrhage are retarded and progressive. For a number of years the conditions of commotion and of compression seem to have been more or less mixed, and it remained in a large measure for Dupuytren and Nélaton, as well as other surgeons of the first half of the present century, to differentiate clearly between the two conditions. Dupuytren had described what he called "contusion of the brain," and his description has remained classical, and the condition to which he alluded was given a place in the classification of cerebral lesions.

Fischer published[1] a theory based upon the result of autopsies and upon a comparison of clinical phenomena, in which he made it appear that the signs of commotion were not practically different from those of shock, which he held to be due to reflex paralysis of the vessels, followed by enlargement of the veins, with consequent alteration in the general circulation, and, later, alteration in the nutrition of the nerve-cells. Fischer demonstrated venous hyperæmia of the brain and membranes in two individuals who died soon after injury to the head, in whom the brain-substance seemed to be absolutely intact. In other words, according to his view, cerebral commotion, or concussion, is simply shock, and its symptoms are due entirely to the vascular conditions present. By the acceptance of this view surgery has been advanced. A little later, in 1874, Koch and Filehne[2] conceived the idea of substituting for the violent blows of previous experimenters rapidly-repeated milder injuries, by which they are able to produce the same clinical results—namely, muscular relaxation, complete insensibility, and circulatory disturbance. The blows were made with the frequency of about two in a second upon the parietal region; after a half or three-quarters of an hour the temperature was always found to have sunk, the respirations to have become slower, and the pulse to have fallen from 58 to 36; the animals lay unconscious, but reacted if allowed to live. Sections gave always appearances of contusion at the point of violence, with congestion of the membranes, the substance of the brain, and the upper portions of the medulla; no vascular ruptures were noted. Their conclusions are succinct: they deny participation of the vascular system in the production of the signs of cerebral commotion, and claim a purely dynamic explanation for the condition included under this name, ascribing only a secondary rôle to vascular phenomena. Of course their work is open to the objection that the conditions are very different as between a single violent blow upon the head and repeated milder blows.

In 1878 appeared the researches of Duret[3] from the anatomical direction. Duret interprets these lesions by a certain elasticity of the cranial vault and by the presence in the brain of the cerebro-spinal fluid. He claims that an impression on one side of the skull, be it of instantaneous duration, due to a blow, is followed by elevation at the point opposite, permitted by a certain elasticity of the bone. He speaks, therefore, of a cone of depression and of elevation. There occurs also a violent precipitation of liquid in the direction of the injury, by which damage is done to the vessels, and even to the substance, of the brain. As the cone of elevation is formed there is a general movement of all the contained fluids of the skull in that direction, in consequence of which there is a very violent distention or elevation of hydraulic pressure in the parts thus affected. Consequently, Duret offers this explanation for commotion: The instantaneous change in the shape of the bone effects an alteration in the size and shape of the ventricles; and their contained liquid, forced out from surrounding pressure, can only escape through the aqueduct of Sylvius, through which it is forced into the fourth ventricle. The effect of this pressure is to produce a condition of shock

[1] *Volkmann's Samml. klin. Vorträge*, 1871, No. 27.
[2] *Archiv f. klin. Chir.*, 1874, xvii. 190.
[3] Duret, *Études expérimentelles et cliniques sur les Traumatismes cérébraux.*

which presents all the phenomena usually ascribed to cerebral commotion: it produces general demoralization of all the muscle-phenomena, as well the voluntary as the involuntary. Studying these phenomena, Duret has divided the effects of cerebral traumatisms into three stages—the stage of excitation, the stage of paralysis, and the stage of reaction. During the first there is a tetanic condition of the muscles, often with violent expulsion of urine and fæces, and sometimes profuse salivation. At the same time there is considerable increase of vascular pressure, as shown by muscular contraction; the heart becomes irregular, Duret having shown that violent shock from the head produces more or less arrest of heart-action and sometimes a respiratory syncope. This stage of excitation—a few seconds or a few minutes in duration—is succeeded by a paralytic stage, during which there are muscular relaxation, insensibility, rapid respiration, slow pulse, vascular relaxation, a paralytic congestion of the brain, etc. Duret has demonstrated this vascular relaxation in animals during this stage. The third stage, one of reaction, is characterized by elevation of temperature and sometimes by symptoms of mental excitement, developing even into delirium or mania.

A recent publication of Miles has for the most part corroborated Duret's views. He believes in reflex anæmia as a result of irritation of the restiform body. He considers the minute hemorrhages often found in the cerebral substance as accidents, and as not the real cause of the symptoms of commotion. Finally, there has been recently (1886) published by Sudre in Bordeaux an exposition of the views of Bouchard of that city, who holds that the symptoms of commotion are largely due to the disposition of the cerebro-spinal fluid. He asks himself why there is in some cases predominance of symptoms of commotion, in others those of contusion. In formulating an answer he shows that the quantity of liquid thrown into the cranium varies with the respiration. Expiration forces a certain amount of fluid out, which returns into the cranium during inspiration; in other words, during expiration there is more intimate contact of the surface of the brain with the bone. A blow received during inspiration, when the brain is more surrounded with fluid, would produce commotion; whereas one received during expiration, when the brain is deprived of its water-bed, would be much more likely to cause serious lesion in the brain itself.

These are the principal theories of to-day concerning cerebral commotion. In France the views of Duret are most widely accepted. In Germany the possibility is widely admitted of a pure type of fatal concussion without lesion. Beck would reserve the name of "contusion" for those cases where the brain itself is directly injured. Most of the English authors decline to consider that concussion can be fatal without the existence of perceptible lesions. Polis's views,[1] which have been formed after considerable experimentation with animals, seems to be that cerebral commotion is practically due to a lack of equilibrium between the brain-centres and the bulb—that, liberated from the conditions under which they normally functionate, and working each for itself independently of other centres, their equilibrium is lost, and they cease to co-ordinate in their operations.

According to the views of Phelps,[2] contusion may occur in three

[1] *Rev. de. Chir.*, Avril, 1894. [2] *N. Y. Med. Journ.*, Jan., 1893.

forms—general, limited, and meningeal, involving the membranes. The limited may be either cortical or subcortical. Two or three forms may coexist in the same case. Limited contusion differs from laceration as a contusion elsewhere differs from a wound. There is no palpable solution of continuity in the brain-fibres, and consequently the hemorrhagic extravasation can only be minute in quantity and very small in form. *For their repair absorption only, and not cicatrization, is required.* Recovery should occur in the majority of cases. Either form of limited contusion occasionally results in abscess. This, with suppurative inflammation of the brain itself or in the brain-substance, is the result of primary injury to the brain, and not secondary to meningeal inflammation extended from the point of fracture. General contusion is more frequent than the limited form, but less frequent than laceration; it is recognized in three post-mortem forms—general hyperæmia with or without œdema, punctate or miliary hemorrhages, and thrombosis of minute cerebral vessels. These occur separately or together.

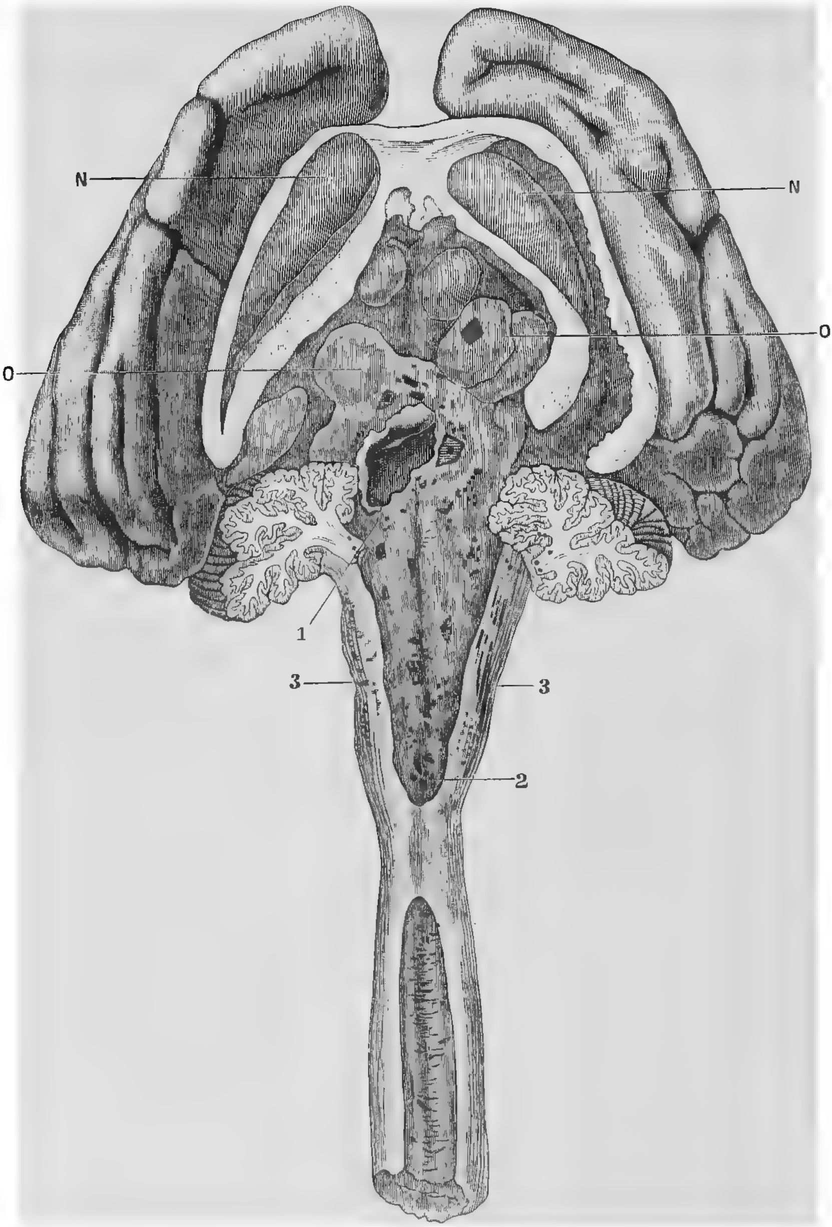
Meningeal contusion as a distinct complication occasions hemorrhage and inflammation. Its relation to general contusion is not closely defined. They may occur together or separately. Hemorrhage is frequent: the vessels of the pia are ruptured, and blood is effused in a rather thin sheet over one or both hemispheres, but may present itself over scattered patches from any part of the brain. When profuse it can easily be traced to its source in the cortical laceration. Phelps claims that cortical traumatic hemorrhage, unconnected with cortical laceration, and without fracture as well as with it, is the result of meningeal contusion. (*Vide* also the illustrations from Duret.)

There is not much to be added here to the above remarks; only a few matters of interest may be briefly discussed. Duret has suggested to describe concussion of the brain as a traumatic cranio-spinal shock (*choc céphalo-rachidien*), impelled thereto partly by remembering that in these cases of violence to the head it is quite possible that the fourth ventricle should be violently, although only momentarily, compressed, and that its contained fluid may either injure the delicate textures about it or may be suddenly and violently forced into the central canal.

Some have suggested that concussion is equivalent to the so-called "compression-apoplexies" of certain authors. These, first described by Bright and Rokitansky, have since been found to have no certain nor definite relations to the phenomena of cranio-spinal shock. In section they are distinguished from more permanent lesions by the fact that they are composed of minute clots, which cannot be washed from the texture of the brain nor pressed out on gentle pressure. Their number is often very large—sometimes, on the other hand, very trifling—and they are, for the most part, limited to the area of brain most injured. Sometimes these minute apoplectic foci constitute the only disturbance we can perceive, but more often they are connected with larger and more visible lesions. This fact indicates the very category in which these minute hemorrhages should be classified—namely, in that of contusion and lacerations, and not that of simple concussion.

Compression-apoplexies are found most often in the region of the medulla and along the floor of the fourth ventricle. In the same way as Duret has explained the occurrence of at least a certain part of the

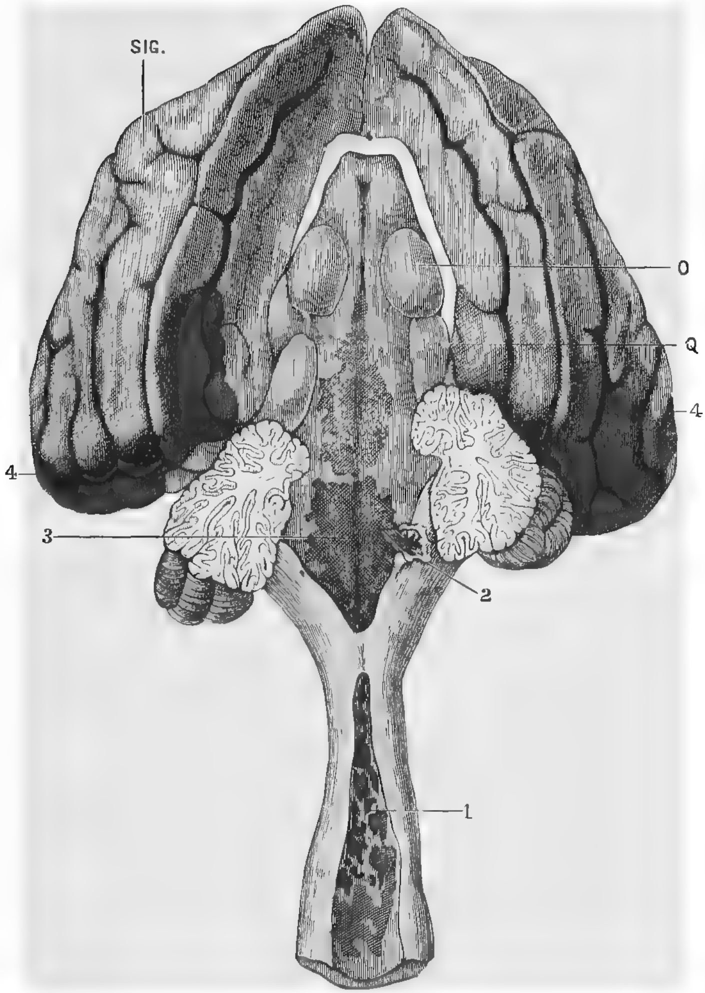
PLATE VI.



Illustrating minute hemorrhages in cerebro-spinal tract and rupture of fourth ventricle, produced by injection of gelatine.

N, Corpus Striatum; O, Thalamus; 1 and 2, Lesions in the medulla; 3, Hemorrhages in the restiform bodies. (Duret.)

PLATE VII.



Surface and interstitial hemorrhages produced by a blow upon the back of the head.

Sig., Sigmoid Gyrus; O, Thalamus; Q, Corpora quadrigemina; 1, Lesions in the central canal of the cord; 2, Rupture of restiform fibres; 3, Bulbar lesions; 4, Large superficial hemorrhages. (Duret.)

shock, by pressure of the fluid out of the fourth ventricle, does he also explain the forcing into the fourth ventricle, from the lateral ventricles, of their contained fluid, so that other injuries may be produced in the same fashion. When Duret injected, through a small opening in the skull, an indefinite and non-absorbable fluid with considerable violence, he produced instantly the symptoms of brain-concussion. The quantity of fluid thus thrown in needed not to be large, if only the temporal region were selected and the injection made with force. In every such case he found in the neighborhood of the fourth ventricle numerous large and small ecchymoses. These experiments of Duret's explain why in men as well as in animals, after injuries to the head, compression-hemorrhages and minute lacerations are so often found in the neighborhood of the vital centres clustered in this region. (See Plates VI. and VII.)

It is *à priori* probable—and experience confirms the deduction—that a pure form of brain-concussion is a great rarity, but that it is most likely to be combined with other lesions of the brain and its adnexa, with hemorrhages, with fractures of the skull, or with other evidences of violence. Consequently, the rule which Bergmann lays down is wise —that in these cases it is not the most conspicuous anatomical lesions which should be regarded as the causes of death, but that these should be judged according to the predominating picture presented by the symptoms of the case. It was in accordance with this general idea that Stromeyer wisely held that the sharp sabre of an Afghan might split the skull and brain of his enemy without rendering him instantly *hors du combat*, while the blunt and heavy weapon of an English dragoon, which could not penetrate a skull and which caused a relatively small laceration of the brain, might nevertheless quickly throw him from his horse on to the ground, and instantly disable him.

The cases of the pure type of concussion which have been fatal without other perceptible injuries in the skull, in the membranes, or in the brain itself are so rare that surgeons of large experience, like Pirogoff, Follin, and Prescott Hewett, actually doubt their existence. Deville, for instance, has reported the case of a man who had been thrown upon the pavement from a height, who was taken into the Hôtel St. Antoine, where he was found to be collapsed and unconscious, but without paralysis or convulsion; he remained in this condition a few hours, and then died. Neither upon his head nor inside of the skull could the slightest lesion be detected, and the attending physician held this to be a case of death from genuine concussion of the brain. Deville could not believe this, and examined the body again, and found in the spinal cavity a large clot of blood. So, too, Hewett saw in St. George's Hospital the autopsy made on a boy who had died two hours after falling from a height, and presenting a typical case of brain-concussion. At two points there were found trifling lesions of the brain; otherwise the brain seemed healthy. But when the thorax was opened, not only was there found a fracture of the ribs, but also a rupture of the heart. And so it is with many other cases which have been recorded, and a much larger number which might have been. In the older literature of this subject fat-embolism does not figure, it having been only comparatively recently studied. How many cases of so-called brain-concussion were, in effect, due to fill-

ing of the pulmonary capillaries with fat? It is known that the symptoms of fat-embolism are in large measure those of shock—*i. e.* those identical with concussion-symptoms. How many of these cases, too, have suffered from degeneration of heart-muscle or lesions of the coronary arteries, which may assume a tremendous importance after even trifling injuries to the head or to other parts of the body!

Symptoms.—The clinical appearances of brain-concussion consist for the most part of disturbances of consciousness and intelligence, varying from a slight sleepiness to complete coma; of universal muscular weakness; lowering of sensibility and irritability; vomiting; prostration; alteration of pulse and of the respiration-rate. We may distinguish clinically between mild and severe cases: in the former we have a condition corresponding to the "stunning," as it is called by the laity. After a fall or a blow upon the head there is dizziness, there are disturbances of vision, and peculiar noises heard in the head; strength is lost; the knees give way; the arms fall helpless; the face is blanched; the eyes lose their expression and the lids drop together; respiration is very faint; the pulse is not easily felt, and is thready, often reduced in rate. This condition does not last long, however: the pulse augments; respiration becomes deeper; the eyelids move; the hands are stretched out; the head is raised; the noises in the ears cease; stars or flames are no longer seen before the eyes; and in a few minutes or hours the patient recovers his former condition, although perhaps for a longer time the motility of the eyes is lessened; and the speech may be disturbed, so that patients stutter or select the wrong words. Renal secretion is rarely interfered with after these milder forms of shock.

Delirium or mental impairment is frequent, and sometimes replaces unconsciousness as the earliest noticeable symptom. It may be violent and simulate alcoholic mania, or it may be mild and coexist with stupor. Nocturnal delirium is the most characteristic form of mental disorder in cases of head-injuries, with more or less disturbance by day, and sometimes lapsing into permanent dementia. It may follow recovery of consciousness or it may succeed active delirium. During the night the patient may require mechanical restraint, while during the day he may be coherent and appear quite rational. Memory, however, is usually disturbed.

In the more severe cases the condition already described becomes more pronounced and comes on, perhaps, instantly. It is now impossible to awaken the patient; even the most powerful external irritants make no impression; loud noises are not heard; bright lights are not seen. The pupils are widely dilated, sometimes increase in size; do not respond to light. Patients can swallow nothing; the general appearance of the face is much like that of a corpse; the surface of the body, and particularly of the extremities, is cold; breathing is regular, but very weak and scarcely observable, perhaps broken now and then by a deep inspiration; the pulse is very small, irregular, and quite often much slower than normal; there is retention of urine and fæces; the patient vomits repeatedly, particularly early in this condition. This may last for hours, sometimes even days; after which reaction occurs, very much more slowly than in the first form above described. In many instances it is finally succeeded by a stage of exaltation or reaction, in which the pulse becomes

too frequent and firm, the temperature somewhat raised, face congested, pupils narrow, and eyes glittering. Now the patient may complain of headache, or of pain and discomfort in various parts of the body. In some instances this congestion extends even into meningeal hyperæmia, and possibly is converted into a meningitis. The longer the comatose condition, the more probable is it in these instances that we have to do with something more than mere concussion. This is particularly true when meningitis follows the condition, since it is extremely questionable whether it is possible for an inflammation of membranes to follow a concussion in which there has been no material lesion.

In diagnosing and prognosing such a case as this, one must proceed with great care upon lines already well marked out. Prognosis will depend in no small degree upon not merely the profundity, but the duration, of the symptoms above mentioned. Whether in the following days or weeks there shall develop a meningitis or an encephalitis in mild or serious degree apparently depends, in large measure, upon the existence of mechanical lesions which are not to be recognized from the outside, but are to be suspected only from the violence of the symptoms.

These are the cases which pass out of the category of concussion, and are with propriety recognized as instances of contusion of the brain—an intermediate form between concussion and compression, which deserves at least a place in clinical surgery, even if its results be somewhat indefinite and difficult of recognition. If stupor increase and if the pulse become more and more involved, and particularly if convulsive movements or paralyses result, one may say with absolute certainty that the case is not one of concussion alone, but that the symptoms of this are yielding to those of contusion or compression, as the character of the internal lesion assumes the phases of the one or the other condition. It is quite easily appreciable how a case may be seen quickly after injury when the symptoms are virtually only those of shock, but in which these may give way to those characteristic of compression as hemorrhage gradually occurs or as minute hemorrhages or hemorrhagic foci are formed. Evans has reported, according to Hewett, a case of an elderly woman who was run over and brought into St. George's Hospital with classical symptoms of concussion, complicated with a wound in the hand. The brain-symptoms soon gave way; the patient became conscious, and completely recovered. Two months later she died of erysipelas, which had developed about the lesion in the hand. Inasmuch as the attending physician doubted whether even in her case there had been a pure type of concussion, an autopsy was carefully made, which revealed unmistakable evidences of extensive hemorrhage into the arachnoid cavity. So generally recognized now is the serious significance of protracted symptoms of concussion that surgeons generally, particularly recent French authors, are learning to regard them as evidences of fracture of the base of the skull.

Diagnosis.—Grievous error has frequently been made in the failure to distinguish between head-injuries and other conditions involving loss of consciousness or delirium, especially alcoholic coma. In differentiating them Phelps claims that coma ought not to be ascribed to alcohol except by the strictest process of exclusion, while the symptoms which

are most likely to characterize head-injuries should be sought seriatim. Temperature is a means of almost absolute diagnosis; in alcoholism the temperature is usually subnormal. In diagnosis of apoplexy and non-traumatic hemorrhages we may accept Bourneville's views, according to which in the commencement of the attack the temperature is subnormal, then becomes normal, and remains at that point if the patient is to recover, whereas if he dies it rises to a marked degree. This is in pronounced contrast to traumatic lesions, in which the temperature rises at once and remains elevated, while the results remain in abeyance. Phelps reports two cases of men who were seized with apoplectic effusion, who fell and lacerated their cerebellums in the fall. There is no one single diagnostic sign as between the delirium of alcoholism and traumatic delirium, and yet there are few head-injuries in which there are not at least one or two characteristic symptoms which can be detected if sufficient care be exercised.

The **treatment** of brain-concussion has been in time past a much discussed theme. Nevertheless, when concussion by itself is properly regarded, it is seen to be only an expression of shock, which by itself calls for the treatment we all recognize as suitable to such condition. In addition to this, of course attention should be given to any external lesions—scalp-wounds and the like—which may call for local treatment. In a general way—the head is kept low; the scalp shaved and carefully examined; the heart is stimulated in any necessary way—in extreme cases by the administration of cardiac stimulants subcutaneously, among which sparteine, strychnine, nitro-glycerin, and atropine rank most highly. The application of heat over the epigastrium or of sinapisms is of assistance. The best way of applying the former is perhaps with a sponge repeatedly soaked in hot water. Solutions of camphor may also be used subcutaneously with advantage. Great care should be used in giving the patient anything by the mouth, since in this condition substances thus administered may enter the larynx instead of the œsophagus and cause much more harm than good. When the surroundings permit it, it is an advantage in extreme cases to put the patient into a hot bath. In a general way, absolute rest and freedom from all excitement in the bedroom should be insisted upon.

I believe, with Phelps, that in a majority of cases involving intra-cranial lesions the indications for trephining are as yet wanting. In the greater number of cases, in which only symptoms of diffused lesions can be recognized, the use of the trephine is impracticable and unjustifiable, unless undertaken for special reasons. If in time lacerations at the base come to be diagnosticated with reasonable certainty, it may then be proper to inquire whether their exposure by the trephine or otherwise would be practicable or advantageous. Nevertheless, the trephine may be used on purely medical grounds. Phelps reports the case of a man who fell from his cab after an apoplectic effusion, causing laceration of the cerebellum. He was unconscious, anæsthetic, and paralyzed. He was trephined, and a large amount of serous fluid drained away from the brain. His temperature fell in six hours from 103.4 to 98.6. He became conscious, could articulate, spoke rationally, gave his name and address, and then in fourteen hours his temperature rose and he died. The possibilities of such a case are not less apparent than dramatic.

BRAIN-PRESSURE; COMPRESSION.

We have already seen how completely the contents of the cranial cavity fill it, and how little space there is which may be occupied by anything in the shape of a foreign body without effecting serious disturbance in the brain and in the tension of the cerebro-spinal fluid. We must insist, first of all, that the symptoms of compression are practically invariably the same, no matter by what induced, and that a diagnosis of compression alone does not necessarily include a diagnosis of the cause of the same.

This condition seems to have been first clearly recognized by Verduc and Boerhaave. Haller noticed in his experiments with animals that after pressing upon the brain they became unconscious and snored. It is possible that he only experimented, as did Astley Cooper, by pressing upon the brain with the finger through trephine openings, the experimented animal showing first pain and irritation, and then, as the pressure became firmer, coma and slowing of the pulse. Flourens experimented on young doves by pressing through the thin and transparent skull-walls with or without previous trephining. As the result of pressure thus made he produced extravasations which could be demonstrated after removal of the bone, and which produced within the brain-cavity the conventional signs of compression. Leyden and Althann have in time past experimented more systematically upon this subject than others.

As the result of experiments, as well as of clinical study, we may state that reduction in the size of the cranial cavity may be produced—

1. By lessening of its cavity as result of alteration in the configuration of its surroundings, whether this be diffuse or local;
2. By increase in the quantity of the cerebro-spinal fluid or of the brain itself, which latter may be produced by œdema, by exudation of serum, or by hypertrophy of the brain.
3. By foreign bodies, which may enter the skull from without, and
4. By pathological conditions, such as hemorrhages, collections of pus, and tumors, which may be produced either from the brain-substance, its membranes, or its vessels, or which may arise from without and produce these disturbances indirectly and in a secondary way—*i. e.* depressed bone.

In every one of these conditions the size or the tension of the brain is affected. The cerebro-spinal fluid is mainly involved in acute, not in chronic, conditions. Osteosclerosis of the cranium may reduce the diameters of the skull without increasing intracranial pressure to a marked degree. The lesions of the bone which affect the brain are, for the most part, necroses or malignant tumors, many of which are capable of removal by operation. So far as compression from *traumatic* influences is concerned, we have at this time and in this place to distinguish mainly between—

1. Compression by extravasation of blood, whose source is to be found in the vessels of the cranial cavity;
2. By fractures of the skull with depression or by foreign bodies penetrating from without; or by

3. The products of acute infectious inflammation accumulating within the skull. (Tumors will be considered separately.)

The general result of all these is increase of intracranial pressure, and the result of this is a less rapid flow of blood and an altered blood-supply to the brain and its membranes. This disturbance in the circulation is connected with two conditions—the amount of the compression or the extent of the compressing material, and the tension of the spinal ligaments, since the spinal canal is distended by the cerebro-spinal fluid forced into it by pressure from above. Some time ago Malgaigne tried to determine how much fluid one could inject into the cranial cavity before producing a dangerous degree of compression. As the result of these experiments he concluded that a compression of the brain by one-sixth of its volume introduced the element of danger, and that even a lesser degree of compression could scarcely occur without injury. Malgaigne's conclusions were modified by Pagenstecher, who used instead of water a non-absorbable material—namely, wax—which he injected between the skull and the dura. The amount which he could introduce without producing pressure-symptoms was in the minimum 2.9 per cent., in the maximum 6.5 per cent., of the cranial contents. This will illustrate why sometimes fractures with depression produce serious symptoms, and why at other times a relatively great degree of depression is followed by a minimum of disturbance.[1]

The tension of the cerebro-spinal fluid approaches closely to, if it does not equal, that of the blood in the capillaries, and thus helps to check hemorrhage so soon as the pressure within and without the vessels is nearly equalized. In fact, it is well known that capillaries need to undergo only a very trifling degree of contraction in order to show very great diminution of stream. According to a well-established law, the velocity of outflow from capillary tubes at similar pressure and in similar length is proportioned to their diameter. That is, when the diameter of a capillary tube is reduced by one-tenth, only half as much fluid flows through it under the same pressure; should it be reduced by one-fifth, the volume is reduced to one-tenth. According, then, to the volume of the compressing material in the skull will depend the dangerous degree of tension of this cerebro-spinal fluid. In the physics of physiology we read often of congestion hyperæmia and relaxation hyperæmia, both of which come into consideration in dealing with these physics of compression. Both of them in the case of the brain may lead to œdema. This is not the case in other parts of the body, but is the result purely of the peculiar circulatory conditions in the brain. In other places paralysis of the vessels does not affect the outflow through the veins nor through the lymphatics; but in the brain œdema easily develops, since a relaxation hyperæmia disturbs the venous stream because of capillary compression. Althann has deduced the following pretty precise statement from his studies: to wit, that for the nourishment of the tissue of the brain it is immaterial whether the accession of arterial blood is hindered by slowing of the circulation or by reduction of its volume; in either case hyperæmia or anæmia interferes with the nourishment of the brain, and finally produces similar disturbances of brain-function. A slow blood-

[1] *Vide*, also, Deucher, "Experimentelles zur Lehre von Gehirndruck," *Deutsche Zeitschrift f. Chirurgie*, xxxv. 145.

current or insufficient nourishment of the brain takes place alike whether the circulation be reduced by obstructions in the skull or by diminished cardiac power; whether the resistance or obstruction be absolutely or relatively too great; whether an augmented intracranial pressure narrows the capillaries; or whether there be reduced arterial tension to overcome the obstruction.

Compression of the brain is, both for the vaso-motor and vagus centres, an irritation which appears to act upon the former first, and then upon the latter. This is of some importance in this connection, since irritation of these centres plays more or less of a part in the production of arterial tension. Later, after both of these centres have been paralyzed, the convulsive centre is affected, as has been shown experimentally by Bastgen.[1]

Pulsations of the venous blood-stream may be produced by a rhythmical alteration of narrowing and dilatation of veins, which is produced as the consequence of an alternating tension of the cerebro-spinal fluid.

C. Phelps[2] believes that concussion and compression should be regarded as one, but he would go farther, and, having consolidated the two conditions, would abolish both terms so far as used to express a pathological condition, the difficulty being that all explanations of concussion are of necessity largely theoretical. In very fatal cases, where the clinical history has corresponded to that of recovering cases of concussion, a carefully conducted necropsy has revealed organic lesions. In all those cases cited to prove that no post-mortem lesions exist not one has been observed with sufficient exactness to make it of any value. There is nothing in analogy to warrant the assumption that any fatal disorder terminates without involving structural changes. It is tenable ground, therefore, to hold that brain-injuries produce certain structural changes with the same certainty that they occasion palpable symptoms. Better, then, he thinks to discard the terms, and to say that in any given case the patient suffers a laceration, contusion, or fracture with hemorrhage. He believes that mere unconsciousness and variation of pulse are not reliable symptoms whereon to found a diagnosis, although doubtless unconsciousness is one of the earliest and most constant symptoms of serious brain-lesions.

The view that consciousness resides in the cortex as a whole, and that unconsciousness is an inhibitory condition or paralytic, is confirmed by the negative results of physiological experiments and by the artificial production of cerebral anæmia.

Temperature seems to Phelps and to other recent writers of primary importance. Analysis of temperature records confirms the impression that elevation of temperature is an early, continuous, and constant symptom in all head-injuries. When temperature is subnormal and subsequently rises *prognosis is bad.* In seventy-two cases of serious fracture temperature on admission was above normal. Phelps gives sufficient data to prove that in practically no condition except sunstroke is the temperature so uniformly high as in cases of encephalic lesions. Unconsciousness is less reliable than variations of temperature. Depres-

[1] *Würzburger Dissertation*, 1879.

[2] *Loc. cit.* Vide also paper by Phelps, "Dif. Diagnosis of Intracranial Lesions," *N. Y. Med. Journ.*, Dec. 22, 1894, et seq.

sion of temperature may, like retardation of pulse, be a primary change, but is too evanescent to be practically diagnostic. In many trivial head-injuries the only symptom for recognition is the temperature, this pyrexia being usually constant, no matter what the lesion nor where located. It would seem to be due to an affection of the cortex, and not to localized heat-centres. The primary effect of severe brain-injuries may therefore still be attributed to an affection of the entire cortex, and is manifested by two symptoms—variation in temperature and nearly invariable loss of consciousness.

Inasmuch, then, as post-mortem observations disclose in every fatal case gross lesions in one or more regions of the brain or its membranes, which furnish a material basis for the symptoms preceding death, it would not be a bad plan to exclude the terms "concussion" and "compression" from systems of classification and case-histories.

Symptoms.—Ever since the experiments of Boerhaave and Haller there has been constituted a nearly constant and diagnostic set of signs and symptoms expressive of brain-pressure. Only in time past two errors have caused some uncertainty. The first proceeded from the idea that the compressing cause would produce symptoms varying with its nature, and the other was the uncertainty introduced through certain mixed cases. It was one of the greatest services which Althann rendered in this matter that he demonstrated that the signs of compression are invariable, no matter what may be the compressing cause. After him, Leyden sought to produce an equable pressure over the entire convexity of the brain by introducing through an experimental opening an exactly measured amount of salt-and-albumin solution, and came to the result that the pressure-symptoms followed each other in a fairly regular order, and that from pressure of similar degree similar symptoms are produced. One of the first of these seems to be the pain which is complained of before pressure is sufficient to cause unconsciousness. The experimental animals at this stage show marked evidences of suffering, which is less often complained of in men because the compression takes place too suddenly or because the patients are already unconscious from production of shock at the instant of injury. This pain is no doubt due to the supply of nerves from the fifth to the dura, since Magendie's experiments have shown that the brain-substance itself is absolutely insensitive. This experiment is of interest in clinical medicine as well, since it explains many cases of pain in the head as well as the generally known fact that these pains are increased by such violent efforts as sneezing, coughing, etc., as with each such effort arterial tension is for the moment increased. Moreover, we have here explained by sensitiveness of the dura the facts that brain-abscess and some other local lesions produce a pain which is a fair index as to the location of the lesion itself. Next to pain—which in human patients is seldom complained of—we have stupor, sopor, and coma. The alteration of consciousness is observed more in actual practice than it is in experimental animals, who have no means of expression. In traumatic cases one observes the symptoms, for the most part, taking the order of irritative, psychic, and then sensory and motor. Thus, for instance, we have irritability, shown by restlessness, by acute sensibility of special sense-organs, noises in the ears, peculiar visual disturbances, then pain in the

head and positive headache. As the blood-pressure increases we find reddening of the face, eyes brighter and with narrow pupils, and frequent pulse; pulsation can often be seen in the carotids, which are quite distended. In proportion to the rapidity with which intracranial space is reduced is that of the succession of symptoms of torpor to those of erethism. Patients next suffer from vomiting, convulsive motions; their thoughts and words go wrong; and finally they fall into a sleep. From this sleep they neither awake nor can be awakened until the compression is relieved. Consciousness may either be lost after the order of events noted above, or it may be suddenly lost, as after an apoplectic attack. In any case it happens so soon as the compression of the capillaries in the centres has reached its height. Practically, all of the above symptoms of brain-pressure, from the first trifling disturbance until absolute coma is reached, are ascribed to involvement of the cortex. We know that this cortex is the seat of consciousness as well as of projection or imagination. During the night of the senses produced by cortical pressure only the automatic apparatus of the basal centres and the spinal cord continues in more or less undisturbed operation. The cerebral cortex is that particular organ of the body which we regard as in need of constant and undisturbed nourishment, whose function is disturbed by the slightest alteration in the same; even the slightest alteration of blood-pressure may produce some disturbance in volition or voluntary activity. With reduction of the blood-stream must occur reduction in tissue-activity and oxidation. Of all the general functions, consciousness vanishes first and returns among the last, and not until the circulation has been completely re-established is it anywhere near perfect again. The necessity for nutrition which the brain-cortex evinces is, in large measure, governed by the peculiar circulation of the same. In the vessels of the pia there may be found a most complete canal system with extensive anastomoses, all of which are supplied from six different sources. From this complex system spring the capillaries which dip into the cerebral tissue, an arrangement which is admirably planned to equalize blood-pressure and to supply blood at a constant tension. But just so soon as the sources of supply are affected, then almost instantly the entire cortical region suffers and its combined functions are altered.

When intracranial pressure has reached a certain point experimentally there are produced epileptic or eclamptic convulsions, varying in intensity, affecting all the limbs, and terminating perhaps with violent extension and opisthotonus. These convulsions, however, are produced only when pressure is very high; during this period convulsions may occur and subside, to be reproduced with every augmentation of tension. In wounded individuals we seldom meet with these peculiar spasms, the explanation for which is not difficult to find. A depression of bone, for instance, especially when quite marked, narrows the cranial cavity to an extent quite capable of altering the circulation; but it is doubtful whether this pressure alone, without any injury, can produce the violent symptoms which we sometimes meet with. The other most common cause of brain-pressure in traumatic cases is extensive extravasation, which occurs always relatively slowly, as in experimental cases, and which when extensive proceeds almost always from the middle menin-

geal artery. On account of its peculiar relations to the bone and the dura there is considerable resistance to outflow of blood, so that an extensive collection can only occur gradually. About the only exceptions to these statements are found in those cases where either in the the brain or in one of the ventricles there has been rupture of vessels, and blood has poured out directly and almost instantly.

On account of the disturbance in motion and of stupor the frequency of the heart's action is reduced. Reduction in frequency of the pulse is one of the most frequent and pathognomonic symptoms of brain-pressure. It is produced from the mechanism of the pneumogastric, which suffers first an irritation and later a paralysis. Leyden's experiments upon the effective division of this nerve are here of no small interest: After the pulse had sunk to 36 without increase of pressure, it rose at once to 168, and remained unaltered in spite of the variations of intracranial pressure. Even before division of the nerve on both sides simultaneously the pulse is slow; after it, two or three times as fast. Kehrer has shown that firm pressure upon the temporal bone of new-born animals will slacken the pulse, which is relieved instantly by division of their pneumogastrics.

Similarly with the heart's action the respiration-rate is reduced; during coma breathing is exceedingly deep, slow, and frequently stertorous. This characteristic snoring is the purely mechanical effect of paralysis, in this instance of the soft palate and uvula, by which they are so relaxed as to drop back in the pharynx and thus be in the way of the stream of air. When the intracranial pressure has reached its height, respiration becomes also irregular, and is for the most part superficial; and there may occur long pauses—even so long as one minute, during which there is no breathing—which are followed by deep inspirations and resumption of irregular breathing. The heart continues to beat even when respiration is thus intermitted from one to two minutes; it continues to beat also for from one to two minutes after the last inspiration in fatal cases. Duret studied the relation of pulse and respiration. He found that when pressure was made, if high, the pulse sank from the beginning, and that the respiration-rate rose, to sink more gradually; as the pressure was gradually raised in his experiments, so the pulse became more frequent and even rapid. It was usually relatively rapid in fatal degrees of tension at about the time when respiration ceased.

Less constant are disturbances of digestion; occasionally vomiting is noticed, sometimes purging. Vomiting is, when met with, seen early, since it occurs before brain-tension has risen to its highest degree. At first, at least, temperature is slightly if at all affected.

Along with the above-mentioned general signs there are more or less local indications, of which the most important are the paralyses. In fact, an accurate diagnosis of compression is founded in large measure upon these, which consist either of monoplegia or hemiplegia, or of more local evidences, such as oculo-motor paralysis, etc. The explanation of this is simple: it means simply pressure upon some limited area or upon an entire hemisphere. For example, a portion of bone may be depressed over one of the motor centres of the cortex in such a way as to lead to paralysis of some particular part of the body. While the general effects of brain-pressure are practically the same, one may have a wide range of local evidences of the same in cases permitting localization. Niemeyer

has reminded us in this connection of the apparent purpose and usefulness of the falx and of the tentorium, by which the cranium is divided into three chambers, as the result of which pressure may be much more manifest in one than in the others. It is the moderately firm resistance of the brain itself which diffuses this pressure through the more or less flexible partitions of the cranium and communicates it to other parts. Those portions of the brain lying nearest the cause of the compression naturally suffer most. Still, any cause which is capable of producing well-marked symptoms of local pressure will also affect the tension of the cerebro-spinal fluid, and thus increase the general expressions of the same.

Experiment has shown much evidence of the possibility of a purely limited or partial brain-pressure.

In spite of theoretical deductions, clinical experience shows that there are often differences to be made out between the pupils.[1] At the outset of compression the pupil on the affected side is injured, and there may also be nystagmus with ocular rotation, until finally the lids close; but when the pressure is raised both pupils dilate, particularly that upon the affected side. Thus, Hutchinson, for instance, has found the pupil dilated on that side where section has shown a hæmatoma between the dura and the bone. A peculiar position of the globe of the eye may also be met with in some of these cases, while there is occasionally a peculiar rolling motion given to the globe, frequently to an extreme degree, seen sometimes in traumatic cases of compression, but more often in cases of traumatic meningitis, quite similar to that met with in cases of tuberculous meningitis in children. Curiously enough, although these clinical evidences may be reproduced experimentally, it is a difficult, if not almost impossible, thing to reproduce experimentally a paralysis of a particular extremity.

Another sign ordinarily of great value in these cases consists of swelling or inflammation of the optic nerve at its entrance into the bulb of the eye. The relations which exist between the intracranial tissues, spaces, and the sheath of the optic nerve, as well as the fact that the retinal vessels are terminal branches of the internal carotid, will do much to explain these phenomena. Choked disk, so called, was thought by Graefe to be the result of pressure in the cavernous sinus with obstruction to the outflow of the retinal veins; but Sesemann showed the regular anastomoses between the ophthalmic veins and the facial, proving thereby that such obstruction could not exist. Later it was shown by several observers that in certain diseases, during which intracranial pressure was increased, there was a dropsy of the optic sheath, and also that

[1] Hutchinson (*London Hospital Reports*, vol. iv. p. 20) was the first to call particular attention to the importance of the pupil as an indication of intracranial pressure. According to the statement of Wiesmann, when marked dilatation of one pupil occurred it was 20 times out of 24 on the side of the extravasation. Along with this there was rare concomitant paralysis of the external ocular muscles. In only 4 cases out of 25 did ptosis or paralysis of the external rectus occur. Sometimes pupillary dilatation will be almost the only evidence as to the side upon which hemorrhage has occurred, and will be perhaps the most reliable guide to trephining. Glycosuria results sometimes from disturbed intracranial circulation. Nagel has reported two cases in which it followed immediately after an apoplectic attack, and disappeared as the clots were absorbed. In Ransohoff's case sugar was met with in the urine soon after the injury, but it disappeared within twelve hours.

by injection of fluid into the subarachnoid space in animals a dilatation and alteration of the retinal veins could be made more visible. It is, though, evident that in intracranial pressure cerebro-spinal fluid forced into the intravaginal spaces of the optic nerve so as to distend the sheath produces compression of the termination of the nerve, and in a little time optic neuritis. This nerve at its entrance into the sclerotic is surrounded by two sheaths, the first of which is a continuation of the pia, the second from the dura. Between the nerve itself and the former lies the continuation of the subarachnoid space; between this sheath and the dural sheath is the continuation of the subdural space. For the production of choked disk it is immaterial which of these cavities is distended. In either case the circulation is disturbed and the result is the same.

A determination of disturbed vision in these diseases, accompanied with intracranial pressure, is of very great clinical importance, and, in fact, is an invaluable sign in certain conditions. It often accompanies hydrocephalus, and its occurrence in the later stages of tubercular basilar meningitis is often to be ascribed to the final effusion of fluid into the ventricles. In view of the intimate relations between the bulb, the optic nerve, and the brain-cavities it is surprising that we have not oftener to deal with disturbances of vision after serious head-injuries. It is most desirable that careful investigation should be made with reference to these lesions in post-mortem examinations. There is but one observation, carefully made, on record which sheds light upon this condition. This was made by Talko.[1] It concerns a Russian soldier who had fallen on the pavement, and who died fourteen hours after the injury. There was watery extravasation externally, and a fracture of the skull extending across the vertex from ear to ear. In the ventricle a free hemorrhage; the sheath of the right optic nerve from the optic foramen to the cribriform plate was filled with blood; the ball of the eye itself was unaltered, but the retinal vessels were hyperæmic. The same condition was found in the left optic nerve, only here the quantity was greater, and the nerve itself was visibly compressed within its sheath; in the left vitreous was an apoplectic extravasation produced by rupture of a retinal vein. Michel[2] was perhaps the first to describe the extension of traumatic extravasation from the subdural space along the optic nerve. In this case the blood had escaped from the depth of the brain through the pia. Panas[3] speaks of four autopsies after severe head-injuries where infiltration of the optic sheath with blood and serum was present, but it is nowhere stated whence this blood came, and not one of the cases is described as one of compression of the brain. One appears to have suffered from brain-concussion and three from fracture, so that Talko's case remains as probably the most instructive and the most carefully studied of all.

Berlin divides these disturbances of vision into three categories: first, those which come on immediately after injury and remain; second, those which come on at once and disappear within a few days; and third, those which are late in their appearance.

[1] *Zehender's klin. Monatsblat.*, 1873, p. 341.
[2] *Wagner's Arch.*, 1873, vol. xiv. p. 57. *Vide*, also, Bergmann, "Ueber Hirndrück," *Arbeiten a. d. Chirurg. klinik Berlin.*, 1886, p. 1.
[3] *Annales d'Oculistique*, 1876, p. 260.

The existence of the first depends upon laceration or other severe injury of the optic nerve. The second group depends upon pressure of blood within the sheath of the nerve, which can probably be reabsorbed; and the third upon later intracranial complications. Unilateral lesions of the optic nerve most often depend upon injuries within the optic canal, while when the lesion is bilateral the cause is usually intracranial, although extravasations have been observed in both sheaths. Berlin collected 86 basal fractures, and found that in 79 of them the roof of the orbit was involved; and that among these 79, 53 times the optic canal was fractured and 42 times there was effusion of blood within the optic sheath. There are certain injuries of the skull which present exquisite signs of compression, in which, however, from beginning to end there is absolutely no sign of choked disk.

From the development of concurrent disturbances with subsequent atrophy we must not overlook the possibility of participation of the retro-ocular tissue, as the result of which we may have a descending neuritis of the optic nerve. Bull[1] noticed the parallelism between tubercular basilar meningitis and the traumatic meningitis of children, both of which are likely to be followed by an exceedingly rapid optic neuritis. In four cases of head-injury with subsequent meningitis he noted choked disk and blindness following. Hughlings Jackson[2] has observed a bilateral optic neuritis in two cases of traumatic brain-abscess. It has also been noted after softening of the cerebellum subsequent to a fall upon the occiput, and after a blow upon the right parietal region followed by degeneration of the entire middle portion of the brain. Galezowski has reported the case of an artillerist wounded in the occiput by a piece of shell, and thereby made blind. Nothing was discovered abnormal in the eye; the patient died in coma. In this case the lesion was undoubtedly a fracture involving the nerves and the optic canals. So far as the general picture of these severe head-injuries is concerned, it is well to remember that amaurosis came on suddenly in 27 out of 43 cases studied by Berlin, in only 1 of which did it disappear.

Course and Prognosis.—Prognosis of cases of compression depends upon a variety of causes which it is not always possible to appreciate. Depression of the bone, especially if it can be obviated by operation, if it produce no other lesion than compression, invites a very favorable prognosis. An extravasation or the formation of a large clot permits favorable prognosis in proportion to its accessibility and the accuracy with which it is appreciated. In fact, prognosis in these cases is largely summed up in the question of whether it is or is not possible to remove the compressing cause. When this is possible the outlook is good; when impossible, it is as bad as can be. In the case of intracranial hemorrhages the future of each case depends upon the volume of the compressing mass and the length of time during which it continues to act. Experiment has shown that a high pressure which may be borne for a few moments is fatal if continued. Deep coma with complete paralysis and loss of sensibility, with dilatation of the pupil and irregular deep respiration, is practically always fatal. So soon as paralysis in the circulatory and respiratory centres has manifested itself the beginning of the end is at hand. Persistence of pressure is not less

[1] *Am. Journ. Med. Sci.*, Oct., 1877. [2] *London Hos. Reports*, vol. iv. p. 380.

dangerous than an extreme degree of the same. When the movement of the blood-current sinks to nearly stagnation the serous elements of the blood escape through the vascular walls of the adventitious spaces, increase the amount of cerebro-spinal fluid, augment its tension, and hinder still more the vital processes; in other words, we have œdema of the brain, which simply increases brain-pressure and brings completely to a stand the ordinary imbibition processes in the cerebral tissue, since Rumpf has shown that lymph-stasis in the peripheral nerves macerates their axis-cylinders and disorganizes their tissue. A little later acute softening comes in as a contributing cause, co-operating with the other results of trauma. General œdema of the brain, which has destroyed so many patients on the second, third, or fourth day after injury to the head, is in these cases of a congestive form, beginning as extravasation inside of the meninges, and still more decreasing available space. During the reaction period which follows the first results of brain-concussion there may occur a congestive hyperæmia, as has already been stated. The accession of blood thus produced increases the already urgent need for nourishment, and still more weakens the circulation. Thus disasters follow each other in a vicious circle.[1]

Local signs of pressure may more or less easily and speedily disappear. If concentrated upon a single limited area, this may suffer intensely, and much more than does the rest of the brain. If, then, this local pressure be relieved and circulation in this part of the brain made more free, resumption of function in this portion will depend largely upon the time elapsed between compression and its operative or other relief. Most often incomplete paralyses are the final results of extravasations which disappear slowly or are too late removed. There are other conditions which influence and alter the prognosis in compression of the brain, some of which are of no small importance, such as disturbance of vascular walls, spreading of inflammation, or occurrence of suppuration.

There is another sign which is important in the consideration of the results of brain-pressure—namely, the acquired tolerance of the brain for pressure. This is seen in certain instances of skull depression where pressure-symptoms have slowly disappeared, although the compressing cause is not removed. Corley[2] mentions the case of a three-year-old child who fell, depressing the entire right parietal bone, so that that side of the skull seemed flat; the child was comatose, with the left side par-

[1] See Kroenlein's classification of hemorrhages (*Zeit. für Chir.*, xxiii. 209). Secondary hemorrhage as a cause of death from this particular injury is a rare accident. It has been known after gunshot wounds so late as twelve or even twenty-one days. In a case reported by Gamgee (*Lancet*, 1875, i. 535) the hemorrhage came from a spurious aneurysm. In a case reported by Lang blood penetrated into the brain through a stabbed wound of the dura, and in a case reported by Alexander (*Surgical Hist. of the War*, i. 314). Perhaps the longest delay before hemorrhage on record was in an injury following an extensive fracture of the temporal region.

In a case reported by Hawse compression of the artery for three hours sufficed, but this could be permitted because of the comatose condition of his patient. Horsley has recently recommended ligation of the carotid for many intracranial hemorrhages (*Brit. Med. Journ.*, 1889, vol. i. 457). Ransohoff found three cases on record in which ligation of the common carotid was made on account of hemorrhage from the middle meningeal. The operators were Bentley, Alexander, and Gamgee. That of Alexander was the only one really successful. Roser suggests tying the external carotid.

[2] *Dublin Med. Journ.*, 1874, p. 306.

alyzed. With careful internal treatment and rest the paralysis gradually disappeared.

Treatment.—So far as the treatment of compression of the brain is concerned, it is practically entirely summed up in one expression—namely, removal of the compressing cause. To be sure, the means by which this may be effected is sometimes more speedily dangerous than the pressure-symptoms themselves; consequently, although the indication is clear, it may not always be possible to carry it out. Quite otherwise is it, however, in the ordinary case of bone-depression or of meningeal hemorrhage, and even in diffuse meningitis or brain-abscess the surgeon may accomplish much.

When one remembers that the result of compression of the brain is really disturbance of the circulation, the question arises easily, Is it not possible to influence this circulation by some means even though the compressing cause cannot be removed? There are instances where more or less can be accomplished in this direction, and, as Bergmann has shown, through the following methods:

1. *Assistance to Venous Outflow.*—It is plain that by increasing the venous outflow from the brain the left side of the heart has less obstacle to overcome in forcing the blood into the brain and through the capillaries. Venesection is a theoretical assistance to this end, and in certain instances has proven of real practical benefit. After the lowering of blood-pressure thus produced, and in spite of reduced volume, the blood more easily passes through the capillaries. When done for this purpose venesection may well be carried out from the temporal veins or from the external jugulars. This, of course, cannot be done if the heart's action be too weak or if arterial tension be already materially reduced. Now, venesection is not practised with the patient's head low, but for this purpose it is well to put him in a semi-upright position.

2. *Stimulation to Resorption of the Cerebro-spinal Fluid.*—If the volume of this fluid can be reduced, compression can evidently be also reduced, for which purpose the endeavor is made to secure profuse absorption and excretion. For this purpose the intestines must be utilized and drastic purgatives are called for. It has been suggested also to put on leeches, which may be applied along the spine or in the regions of the large emissaries for the skull.

3. *Employment of Agents which Contract the Arteries, and so Hinder Circulation through them.*—In other words, the increase of vascular tonus, which is effected for the most part by subcutaneous use of ergotine and of atropine. The constant current has also been suggested for this purpose, applied to the cervical sympathetic along the inner border of the sterno-mastoid at its upper end. The physiological action of cold may also be secured, if possible, and in the conventional ways.

The removal of the compressing cause means, of course, operative interference, which (or so much of it as has not already been considered) will be considered under a separate title.

Injuries of Intracranial Vessels and Sinuses.

INTRACRANIAL HEMORRHAGES.

Intracranial hemorrhages may occur as follows:

1. From external sources through the broken bone or between the dura and the bone—*extradural;*
2. Beneath the dura, between the membranes, or into their tissues—*subdural;*
3. Into the brain-substance proper or into the ventricles.

The vessels whose injuries come most often under consideration in these respects are the sinuses, meningeal arteries, the lesser vessels supplying the membranes and cortex, and in rare instances the internal carotid. The sinus-walls may be ruptured, and bleeding from the sinuses may occur either through substances forced in from without, by splinters of bone, or by simple stretching and laceration. Instruments and foreign bodies from without most often injure the longitudinal sinus; quite rarely the transverse. Injuries of this kind play a part in ancient surgical literature. The old masters of surgery used to reckon nine points upon the skull where one might not dare to trephine, among them the regions of the sutures and the sinuses, where fatal hemorrhage was feared; in spite of which, in those early days, instruments were often applied over the lines of suture and along the sinuses without the dreaded hemorrhage resulting. In fact, the then dreaded accident not happening, men suggested a little later to take advantage of these narrow escapes, and to tap not merely the veins in the neck, but the sinuses themselves; in consequence of which advice the literature of sinus-lesions at one time became quite extensive.

To-day we know that when the longitudinal sinus is opened there is seldom, if ever, any serious difficulty in checking hemorrhage, since slight pressure with a tampon is enough for this purpose. Moreover, the sinus is now frequently attacked in operation, is double ligated and divided, or in the few instances when the source of bleeding has been inaccessible pressure-forceps have been left *in sitû* for two or three days, and then removed with change of dressings. This has been my own experience in at least one case, which progressed without the slightest disturbance. It may also be closed with a fine curved needle and suture. Navratil reports[1] a twenty-four-year-old girl with composite fracture of the skull and penetration of the sinus by a spicule of bone. He sutured the dural wound with a deep continuous suture, so that the sinus was included in the same. During this suture, after removal of the spicule, hemorrhage was prevented by tamponing. At the completion of the suture the tampon was removed, and the hemorrhage was seen to be controlled. The patient recovered.

Although hemorrhage from this source may be free, fatal results should be most exceptional. We must remember that it is possible for blood under these circumstances to escape not only externally, but beneath the dura; also that, as the result of bleeding and consequent stasis with the ensuing coagulation, thrombosis and embolic pyæmia are possible. An exceedingly rare complication of these injuries has been

[1] *Chirurgische Beiträge.*

air-embolism, occurring through the opened sinus. This occurred in one case in Volkmann's clinic, reported by Genzmer,[1] during the extirpation of a sarcoma of the dura where the falx was divided, after which there was a characteristic sucking sound, followed by collapse, from which the patient did not awake. At the subsequent examination bubbles of air were seen to escape from the head when it was held under water. Before this can happen, however, it is necessary that the blood-pressure should sink very low, almost to nothing. Bergmann has also reported a case of a man whose occiput was badly injured: upon entrance into the hospital he was bleeding from the nose and mouth, and he died in four hours. At the autopsy œdema of both lungs was found, while careful investigation revealed a very extensive minute form of air-embolism, the air probably entering through the injured torcular.

MacKenzie has mentioned a case of injury of the cavernous sinus by a penetrating wound through the orbit; Pamard, another—both of which ended fatally. These sinuses are sometimes injured by splinters of bone, cases of this kind having been reported by Prescott Hewett, Reid,[2] and by numerous others. In a very few instances this accident has occurred without external evidence of fracture. One such case was reported by Pott, who found a small tumor upon the skull of a nine-year-old boy which had developed soon after a blow, with perforation of the bone. He laid this bare, and found the tumor to consist of blood which had escaped slowly from a fissure; after removal of bone by the trephine he found the source of the bleeding to be the longitudinal sinus, which had been penetrated by a small fragment of bone.[3]

Oftener, perhaps, than perforation from without occurs rupture of the various sinuses. This may occur even during birth as the result of the pushing together of the cranial bones during parturition. Litzmann twice saw the longitudinal sinus torn apart in cases where there was narrowed flat pelvis with the promontory so arranged as to make deep pressure upon the side of the head; in consequence of which the sagittal border of the parietal bone, which was sharp, pierced completely through its coverings, and both children were born bleeding to death. Bergmann relates several other cases where the longitudinal sinus was torn, and two in which the injury concerned the transverse sinus. As a matter of experience it would seem that the latter is the more frequently injured, the cause of the same being the direction of the violence, which is usually applied from above and behind, as the result of which the skull is compressed in a downward direction from right to left, or so stretched that the transverse sinus is torn across.

The **symptoms** which indicate a collection of any considerable amount of blood within the skull, especially from a sinus, are practically indistinguishable from those produced by meningeal hemorrhages, the only distinction between them being that the former occur more slowly, the latter more rapidly. In fact, it does not necessarily follow that every minute wound of a sinus-wall will produce serious hemorrhage; experimentally, it certainly is not so. This question is one of no small practical interest. In opposition to this also it must be acknowledged that there are at least two cases on record where autopsy revealed injury

[1] *Verhandl. der Deutschen Gesel. f. Chir.*, 1877, p. 32.
[2] *Edin. Med. Journ.*, April, 1864. [3] *Vide* also Bergmann, *l. c.*, p. 366.

of sinus-walls of which during life there was not the slightest evidence.

Concerning the results of sinus-laceration, it must be emphasized that these venous channels may heal without obliteration. Experimental researches show a thickening of their walls, but very often a patulousness

FIG. 424.

Clot outside of dura (Wood Museum).

of the canals. This is quite in agreement with cases related in surgical literature and with personal experiences, which show that strictures or complete obliterations, even of the largest sinuses, do not necessarily cause any perceptible variation in brain-functions. The principal danger after hemorrhage is once checked is in thrombosis with softening of thrombi—a danger which is, however, even greater in the instance of the smaller veins of the diploë. With the introduction of aseptic methods this danger in operative cases has almost vanished.

Injuries of the middle meningeal artery reveal themselves solely in the immediate neighborhood of this vessel. Gross collected[1] 8 cases, of which 7 consisted of direct injury to the vessel. Later experiences have shown, however, that the vessel may be ruptured on the side opposite to the external injury and by contrecoup. These fractures produce such lesions in two ways: first, by the sharp borders of bone-fragments, detached or not, which cut through the vessel; or, second, by the sudden alteration in shape which the skull sustains when violently injured. The museum of Freiburg contains a preparation showing a fissure extending along the left parietal bone, which follows exactly the course of the groove for the meningeal artery, although in this instance the artery itself was uninjured. Indeed, Warren has stated that basal fractures often follow the lines of these grooves.[2] It follows, then, that the bone may be weakened along this line, and that in some instances the vessel may thus be injured. These lesions occur not only in well-marked depressions, but even when the inner table alone is broken or in connection with mere fissures. It is not necessary that the bone should actually

[1] *Am. Med. Journ.*, July, 1873. [2] *Am. Journ. Med. Sci.*, May, 1890.

PLATE VIII.

FIG. I.

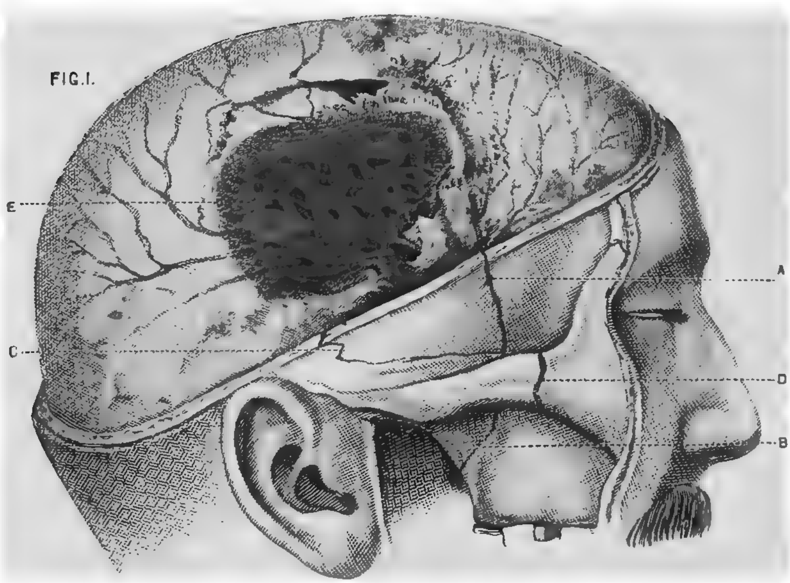


FIG 2.

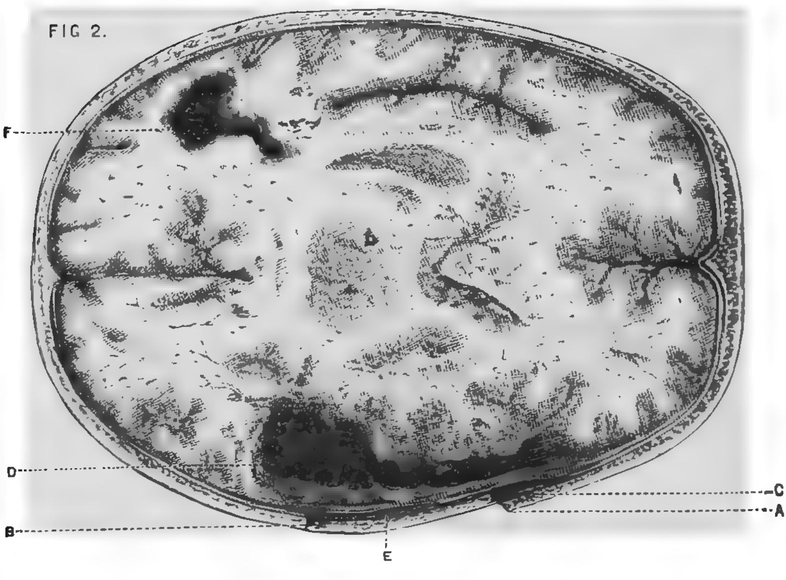


FIG. I.—Compound fracture of cranium, with depression; fracture of bones of face; extra-dural clot from rupture of middle meningeal artery. (Anger.)

FIG. 2.—Horizontal section of same, showing depressed fracture of bone; C, extra-dural clot; D, laceration of brain substance with extensive intracerebral clot; F, same condition produced by *contrecoup*. Punctate hemorrhages and minute lacerations at numerous points, characteristic of *contusion* of the brain. (Anger.)

break in order that the artery itself should suffer: blows upon one temple often injure the vessel on the other side, as do falls upon the occiput, without the line of fissure extending near to the position of the vessel. The point at which this trunk is most commonly injured corresponds to its course along the parietal bone. The anterior is the more often injured branch. It seems to make but little difference clinically whether the principal trunk or one of its branches be torn. Of all the extravasations of blood which occur between the dura and the bone, those from this vessel constitute not only the numerical majority, but nearly the only ones of serious significance. Hewett studied 31 cases of extensive extradural clot, and found that in 27 of them the blood came from this source. The amount of extravasated blood varies within wide limits, and will depend in some measure upon the size of the lacerated vessel. At least 240 grams of blood-clot have been known to collect under these circumstances, and the dura has been found separated through the course of the artery down to the cerebellum (Plate VIII.). I have myself taken out from a case of this kind nearly a teacupful of blood-clot. It often happens that injury to the meningeal artery is not the only lesion, since we frequently have cortical injuries or lacerations. Of the 27 cases studied by Hewett, in only 2 instances did he find meningeal lesion without coincident brain-injury. The symptoms of this hemorrhage are particularly clear when there is coincident external lesion. Jacobson found in 8 cases out of 70 that hemorrhage occurred without fracture, and that in 38 out of 62 the base of the skull was involved.[1] He also found that the main trunk of the artery is rarely injured. Extravasation may be (*a*) rapid and quickly fatal; (*b*) delayed for some time; (*c*) may take place in two stages, the first slight and producing no coma. New clots are nearly always dark and disk-shaped, thick in the middle and with a definite margin; old clots are hard and adherent and difficult to remove.[2] Only when there has been serious compound fracture in the temporal region can there be doubt as to whether an externally visible hæmatoma is due to a temporal or to a meningeal artery. Blood poured out within the skull tends to separate the dura from the bone over an area of more or less considerable extent; it only penetrates without when there is an opening through the skull. Under these circumstances the internal clot may be small and the external clot large. These cases of intracranial clot produce the most typical pictures of brain-pressure.

Symptoms.—According to Jacobson, these consist of—

a. Interval of consciousness or lucidity after injury;
b. Epileptic or spastic symptoms;
c. Condition of pupils;
d. Character of pulse;
e. Unconsciousness, passing into coma;
f. Character of respiration;
g. State of scalp.

The full importance of the first symptom must not be overlooked. When the first concussion is severe and lasts for a long time, it may not be marked. During this interval a child has been known to eat his dinner, and patients have had scalp wounds dressed and walked away

[1] *Guy's Hosp. Reports*, vol. xliii.
[2] *Vide Internat. Med. Mag.*, March, 1893, p. 116.

from the hospital. Patients have been allowed to sleep and become comatose without waking. Froelich reports the case of a man who was hit on the head with a cane, who afterward walked about for an hour and a half, came home, became comatose, and died in five hours. At the autopsy only a large clot was found. Concerning the second, simple hemiplegia is always indicative. Rigidity of the limbs combined with convulsive moments indicates the involvement of brain-substance. When the pupils are natural in reaction the compression is not severe; when dilated and insensitive, it is extreme.[1] Variation in size is a sign of great importance. Hutchinson has explained it by pressure on the trunk of the third nerve, but this is open to doubt, since it has been noted when such pressure could not have occurred. In uncomplicated pressure-cases the pulse is usually about 40, but in serious brain-laceration or contusion it is particularly rapid and feeble. Coma comes on slowly or rapidly, according to the size of the artery ruptured. Commencing coma may be mistaken for natural sleep, and the patient allowed to lie until too late. It has also been mistaken for drunkenness. If it comes on late, it is usually sudden and rapidly fatal. Respiration, which is usually stertorous, is sometimes slow, sometimes rapid, but usually ceases suddenly.[2] In the absence of history the condition of the scalp may be very indicative. Ecchymoses, and above all pulpy spots, over the lateral region of the skull of course suggest injury sufficient to cause hemorrhage. Sometimes this may make its way through a fissure of the skull, as in fluctuating tumor. Incision of all pulpy places, therefore, is always proper. Even if no fracture is found, the trephine should be used.

As showing how relatively slight injury may produce hemorrhage, I would place on record here the case of a man shown by me to the American Surgical Association in 1893. A working-man about fifty years old, returning from work, slipped on the sidewalk, fell, striking on the back of his head, was stunned for a moment, helped himself up, walked two miles to his home. Not until next day did he begin to act strangely; then became successively restless, wandering in speech, apathetic, stupid, and comatose. On the fourth day he was sent to my clinic, when I trephined 6 ctm. above the left ear. I found an immense extradural clot extending backward. So large was it that even through a large opening I could not remove it all. I made then another opening in the occipital region. Finally, with probes, sharp spoons, forceps, and a powerful irrigating stream, I removed a good teacupful of firm, dense clot. Through-and-through drainage was made for two days, by which time the depressed brain rose to its proper level. The patient made a rapid and uninterrupted recovery, and was at work within a month.

A case of serious character was reported by Perrin of an officer who, during the storming of the Malakoff, was struck in the head by a piece of shell, fell unconscious, recovered after a few moments, declared that he felt as well as ever, and resumed the fight. After a while he fell again, became unconscious, and was paralyzed on the opposite side, and displayed the usual pressure-symptoms. He finally recovered.

Hemiplegia is one of the most characteristic signs of this condition. This may be caused by pressure upon the cortex, which produces

[1] *Vide* Vogt, "Arteria Mening. med. Zerreis.," *Deutsche Zeitschft. f. Chirurgie*, ii. 165.
[2] *Internat. Med. Mag.*, March, 1873.

anæmia, and thus loss of function or the symptoms of injury of the motor area of the cortex. So long, however, as blood-clot does not press upon the Rolandic region, especially when it occurs from the posterior branch of the artery, one may meet with an extensive collection extending even to the base without such distinctive or characteristic symptoms. As has been stated, the clinical picture of compression from this cause is usually quite distinct, the pause between the injury and its final results being very characteristic, failing only under certain well-known circumstances.

In February, 1889, a young man in a neighboring town was injured by a falling board, which inflicted a large scalp wound near the left parietal eminence. He was stunned, but quickly recovered consciousness. He was then put on the train and sent to the Buffalo General Hospital, which he reached in the evening. On his arrival at the station, where he was met by the ambulance, it was noted that he used his right arm, but that during the quarter of an hour spent in the removal to the institution he lost the use of it. When he entered the hospital he was able to talk, but within half an hour he lost his power of speech, and within an hour was completely aphasic, with right brachial monoplegia. I did not see him until the following morning. His condition had not become aggravated during the night. Naturally, the diagnosis was that of clot pressing upon certain centres, and the indication for operation was most plain. I found a depressed fracture about the size of a nickel five-cent piece. The trephine was applied at a point over the arm-centre and speech-centre, and a portion of slightly depressed bone was removed, its inner table being considerably splintered. There was no laceration of the dura, which, however, was dark in hue and bulged into the wound. Upon making a small incision a piece of clot was expelled from the dural wound and literally ejected to a distance of fifteen or eighteen inches, showing the degree of intracranial pressure. Enlarging the incision, a considerable quantity of clot, fully two tablespoonfuls, was removed with probe, spoon, and irrigating stream. A number of small brain-fragments were also extruded, showing that there had been laceration beneath the unbroken dura.

A lad of fifteen was struck on the right side of his head by a wagon, and was unconscious for a time. There was no distinct scalp wound, only some bruising and ecchymosis. I saw him six days later. In the mean time no motor nor localizing symptoms had developed, but on the previous day his temperature had begun to rise, and he had become very peevish and restless, although he was up and about the house. I could easily feel a flattened and depressed area back of the right parietal eminence. After shaving the scalp it was found ecchymotic above and behind the ear. On raising it the periosteum was found separated from the underlying bone, and an irregular, V-shaped, linear fissure with depression was found. The trephine was applied 5 cm. away from the ear, on a line from the meatus to the bregma. Immediately upon raising the button of bone I came upon a very firm extradural clot in which organization had begun, and which, after cutting away a large amount of bone, I found to cover an area 6 by 10 cm. (equal to 60 sq. cm.), and to be at least $1\frac{1}{2}$ cm. thick in its central portion. So tenacious was it that it was removed only with considerable difficulty. After its removal

the brain did not at once rise to its proper level, and I did not think it necessary to open the dura. The wound was closed without drainage, and rapid and perfect recovery ensued.

Bergmann has gathered together 98 carefully-recorded cases of clot from meningeal hemorrhage. Of these, 16 terminated favorably; in 12 of them the blood escaped externally; 3 were trephined successfully, and the remaining 1 is Perrin's case reported above—the only instance out of 99 in which recovery followed a concealed hemorrhage in which no operative procedure was resorted to.

It has been shown in another place how these extradural extravasations may be followed later by a certain amount of absorption with production of osteophytes. In fact, when the extravasation is extensive there is almost always a ring of ossification around its border, especially when the patient is young. When these extravasations break down we have extradural abscesses, which frequently are followed by meningeal affection and fatal cerebral complications. Sometimes there is burrowing of the pus thus produced, with destruction of the overlying bone, possibly even at considerable distance from the original seat of the injury.

It is further well known to pathologists that inside of the cranium, as elsewhere, old clots may undergo complete cystic transformation, so that nothing but a sac-wall filled with usually colorless fluid marks the site of the previous hemorrhage. The condition is not an uncommon one, and the following case of my own will illustrate some of its phases.

The first case operated upon in this country in accordance with the principles of cerebral localization was a patient upon whom I operated Nov. 16, 1886:[1] It was a man of forty-seven, who more than a year previously had been thrown and dragged upon the ground. Four hours later he became unconscious, although there was no external violence to the skull. He was unconscious for sixty-eight hours, and gradually recovered. He developed nearly absolute aphasia, his vocabulary being limited to perhaps half a dozen words. His right arm was also paralyzed and cold. His epileptic condition developed four months after his injury and became very pronounced. His lesion was diagnosticated as cystic degeneration of a clot, and its position correctly determined. Upon trephining it was found as expected, only perhaps larger. A cyst was discovered with capacity of 40 c. c. of fluid, in dimensions 10 by 3 cm. It was dissected out, and the patient made a perfect recovery from the operation. His epileptic and aphasic condition, however, has since then only in some measure improved. The aphasia is probably caused by atrophy of the third frontal convolution, due to pressure of the cyst. For the epileptic condition I can give no more satisfactory explanation than in any such case.

The principal cause of death, which may occur after a few days or not until after several weeks, is progressive œdema of the brain, which may come on rather suddenly or gradually. It may also be a result of a secondary hemorrhage, which, however, in these cases is quite rare.

Treatment.—Realizing the great danger of meningeal or of intracranial hemorrhage and the fact that most of these cases are fatal when left

[1] Vide *Trans. Cong. Am. Phys. and Surg.*, vol. i. p. 285.

alone, the treatment should be the most rapid possible operative relief. Wiesmann[1] has collected a most significant series of 257 cases of intracranial hemorrhage, of which 147 were treated expectantly, 131 dying, while of 110 cases operated on only 30 died. Can anything speak more eloquently for operation than such statistics? Should hemorrhage occur externally through a wound of the soft parts, this wound may be utilized in order to make access to the deeper parts. If, however, the bleeding be entirely internal, one must quickly prepare for operation, which should consist of trephining over the course of the vessel or over those centres where compression most reveals itself, and must be prepared to remove any amount of clot present, and, if necessary, to expose the vessel should it still be bleeding and secure it. If seen very early, it will be necessary probably to tie the artery; if not seen for three or four days, we may suppose the artery to have been already occluded. Should circumstances make it impracticable to follow out this procedure, we may imitate the example of some of the military surgeons during our Civil War and ligate the common carotid. During the war it was done seven times, with success in three instances.[2] After opening the skull the hemorrhage will probably be found extradural. After removing all this clot—which may be removed partly with forceps, partly with the spoon, sometimes with the aid of a wire loop with which the clot may be broken down, or partly perhaps by the aid of an irrigating stream—if the dura be evidently concealing a clot inside of it, which may sometimes be told by its color, its tension, or its appearance, it will be quite justifiable to incise it and to remove any extradural clot.[3]

[1] *Deutsche Zeitschft. f. Chir.*, vol. xxii. p. 96.

[2] *Vide* Starr, *Brain Surgery*. p. 157; also Krönlein, "Ueber Trepanation bei Blutungen aus der Arteria Mening. med.," *Deutsche Zeitschft. f. Chirurgie*, xxxiii. 209.

[3] *Surgical Anatomy of the Middle Meningeal Artery.*—Steiner (*Archiv für klin. Chirurgie*, vol. xl. p. 801) shows at some length that the course of this artery is by no means constant, and that variations are quite common. It is usually accompanied by two veins in its passage through the foramen spinosum. Here it divides commonly into two principal branches, anterior and posterior, usually about 1 cm. above the foramen. The one takes a direction toward the anterior and lower angle of the temporal bone; the other runs more or less backward along the parietal bone. Careful observation shows that the posterior branch is always smaller than the anterior, and that in the deep division of the artery the anterior branch takes the place of the principal stem. In 8 per cent. of cases the division takes place so high as from $3\frac{1}{2}$ to 5 cm. above the foramen. The anterior branch in a part of its course is often accompanied by a small spheno-parietal venous sinus, which may often be double. Not infrequently this little sinus spreads out underneath the bone, and may be easily injured by the surgeon, as Roser and Malgaigne have shown the difference between hemorrhage of this sinus and that from the artery itself.

The posterior branch is that of most common interest to the surgeon. Whether it runs in the dura or in the canal in the bone, it sends out a certain number of perforating small branches, which pass through the bone and communicate with the extracranial vessels. These minute vessels run sometimes in the occipito-mastoid suture, where they may be detected in their little foramina. Another branch penetrates the bone and connects with the superficial temporal artery. Injury to this posterior branch produces about the same effusion of blood as injury to the principal stem. Of the various anomalies of the middle meningeal artery, the most common is a very high or a very low division into its principal branches. In either case the location of the vessels is different from that ordinarily laid down in the books. The most important anomaly is that by which the middle meningeal and the ophthalmic arteries arise from a common trunk. This is more frequently the case than is generally recognized.

Steiner then discusses the various methods of determining the location of the middle meningeal artery as given by various authors, and he shows that, while most of them would expose the posterior branch—the one usually sought for in its average position—

Credit should be given to the man who many years ago carried out the principles upon which the most modern cerebral surgery is now firmly grounded. For instance, Golding Bird trephined on the sixth day a fourteen-year-old boy who had fallen upon the occiput, was unconscious, and was paralyzed on the right side, with dilatation of the left pupil. There was fluctuation over the left temporal region, and he incised here and removed a considerable external clot. Then he trephined, although there was no fracture visible, and, after opening the skull, took away a much larger internal clot. The patient rapidly recovered. In the *Clinic*[1] Parcels relates the case of a man who continued to work for twenty minutes after receiving a blow upon the head, and then vomited and lost consciousness; he died with symptoms of steadily increasing compression. On section it was found that not the meningeal artery, but the transverse sinus, was torn. The blood-clot in his case weighed 180 grams. Bergmann holds that even here it would have been wise to trephine and remove the clot, although checking of actual hemorrhage would have been more difficult than had it proceeded from the meningeal artery. One of the most instructive cases on record is that reported by Parker,[2] who, inferring that he had to do with a meningeal hemorrhage in spite of absence of external indications, trephined first on the right side over the artery, but found no clot; he immediately trephined in the corresponding position on the left side; found nothing between the dura and the bone, but, noticing that the dura was distended and discolored, he incised it and removed a large subdural extravasation. Within three hours the patient recovered consciousness, and later was restored to perfect health. I cannot agree with the rather doubtful position which Bergmann assumes concerning the wisdom of Parker's course in this case, but am convinced that in case of doubt it is better to open in two or more places than it is to leave a clot undiscovered. Nevertheless, it must be acknowledged that when pressure-symptoms develop a day or two after the receipt of a complicated fracture it is more likely that they are produced by congestion or by purulent meningitis than by a late hemorrhage; in spite of which, however, one would make no mistake in trephining should purulent meningitis be present, since the fact has been clearly established by S. W. Gross that lives have been saved by this very procedure in these cases.

Where shall we trephine? This must be decided by individual symptoms and signs, but the trephine must be applied, if nowhere else, over the area indicated as involved, according to the principles of cerebral localization. Vogt and Beck have suggested trephining at a point one and a half inches above the zygoma and the same distance behind the angle of the orbit. An inch trephine at this point is sure to expose

they would fail to give access to it in case of any of the anomalies which he so well describes. He then gives the following method, which is worthy of notice:

Draw a line from the middle of the glabella to the apex of the mastoid process. This is usually 16 to 17 cm. At the middle of this line erect a perpendicular. Draw another line from the glabella directly backward parallel to the base-line of the skull. Where the second line covers this is the point at which the trephine should be applied to reach the anterior branch. The point at which the posterior branch may best be reached is found at the junction of the line drawn directly backward from the glabella and another drawn perpendicular to it from the tip of the mastoid. In order to draw this last line correctly upon the skull the cartilages of the ear must be pulled forward.

[1] 1874, Sept. 12.

[2] *Med. Times*, 1877, vol. i. p. 91.

the anterior branch of the middle meningeal artery.[1] Nevertheless, the removal of the clot which causes the compression is much more important than merely finding the artery. Krönlein has made the suggestion of trephining twice, if necessary, in those cases in which the chance of finding the clot is good. He divides these hæmatomata generally into three classes: (1) fronto-temporal; (2) temporo-parietal; (3) parieto-occipital. He suggests trephining over the artery first, and then, if no hæmatoma be found and the indications still point to meningeal hemorrhage, to trephine again just below the parietal eminence, because an opening in this position would expose either of the latter classes of blood-tumors. Ransohoff[2] reports a case of a patient who, having fallen eight feet upon his head, presented a typical picture of cerebral compression from intracranial hemorrhage. A large flap was raised, the middle meningeal artery exposed, as well as the clot, which was removed with considerable difficulty on account of its tenacity. Six hours later the patient recovered consciousness. Nine days later, while the patient was straining at stool, there came an alarming secondary hemorrhage by which the dressing was saturated with blood. On the following day this was repeated, but not so seriously, and yielded to packing. Upon the same day the opening was enlarged, and the source of hemorrhage sought for without success. Bleeding, however, yielded instantly to pressure upon the carotid. Accordingly, the common carotid was tied with catgut, and hemorrhage ceased at once. During the emergency incident to this case the wound became infected, suppuration resulted, and the patient finally succumbed to embolic anæmia and general infection.

Injuries of the carotid within the cranium are, of course, exceedingly rare as compared with those of the meningeal artery, and their prognosis is obviously much worse, since very few patients survive such injury. The artery has been found injured by various perforating substances, most of which have entered through the orbit. Longmore has related (*Holmes' System*) that a ball penetrated through the orbit into the petrous portion and remained lodged there, which later caused erosion of this artery and fatal hemorrhage.[3]

In Bryant's work is related the case of a man dying two hours after injury who had a fissure of the petrous portion with separation of the carotid artery. Laceration of this trunk by splinters of bone has also been repeatedly observed. Beck, for instance, has reported an instance where, several weeks after injury, the apparently well patient was suddenly seized with appearances of brain-pressure, and quickly died. A splinter of fractured bone was found to have penetrated the internal carotid and to have given rise to the fatal hemorrhage.

No little interest attaches to the development of arterio-venous aneurysms after injury to the arteries and sinuses of the brain. They often give rise to pulsating exophthalmos, of which Bergmann has collected three cases. For instance, the following is reported by Nélaton: A twenty-one-year-old man received injury by the point of an umbrella which penetrated the right upper lid; free hemorrhage followed from

[1] *Deutsch. Zeitschft. f. Chir.*, vol. xxiv. [2] *Archiv für klin. Chir.*, vol. xlii.

[3] Consult also Beck, *Schädelverletz.*, 1877, p. 55; Zander and Geissler, *Verletzungen des Auges*, p. 301; and Berlin, "Verletz. der Orbita," in *Graefe und Saemisch's Sammelwerk.*

the nose and there was ptosis of this lid. The wound quickly healed; then the right eye began to protrude, its pupil was dilated, and the patient suffered from double vision and strabismus externus. Two months later the veins of the upper lid were dilated and the eye protruded; a distinct murmur was heard, but no bruit. Patient died of continuous nasal hemorrhage, which even compression of the carotid could not check. It was found that the internal carotid had been perforated by the foreign body in the cavernous sinus, from which blood had entered the sphenoidal cells and so escaped by the nose, and that an aneurysm had developed back of the eye.

Pulsating tumors involving the orbit, which press the eye forward and present positive pulsation with a murmur, are not infrequently met with after serious head-injuries. Rivington[1] has collected 73 cases of these tumors, of which 41 had a traumatic origin. Of these 41, 8 were produced by a direct lesion of the orbit; 33 by blows upon the head, among which in 29 times there were symptoms of basal fracture; and of these 29, in 17 instances the diagnosis was positively made. In 3 of his cases the pulsating exophthalmos was bilateral. It would seem that there is always an interval of at least a few days between the reception of injury and the development of the tumor and protrusion of the globe. In the cases studied by Rivington, in 12 instances this interval was twelve days; in 15 instances, from four to six weeks; in 1 case, so long as eight months. According to Schalkhauer,[2] one significant symptom of this condition is paralysis of the abducens. He determined that this is particularly exposed at just that point where it lies close to the vessel in the carotid canal at the point where the artery makes its S-shaped turn. So far as the treatment of these cases is concerned, Nieden found that by ligature of the common carotid 33 out of 49 patients were cured, 6 improved, 3 remained without result, and 7 died.

SUBDURAL HEMORRHAGES.

Subdural hemorrhages are by no means uncommon in the skulls of the new-born, and constitute the so-called "apoplexia neonatorum," the causes for which lie not so much in increase of blood-pressure as in vascular rupture, which is directly connected with pressure from the umbilical cord in rare cases, or more often with pressure upon the head during birth. In these instances it is especially the veins which run through the subarachnoidean space which are stretched and torn. Virchow was among the first—was perhaps the first—to show the significance of this hemorrhage, of which he found a typical instance in a twenty-nine-day-old child dying of multiple abscesses of the head. The recognition of this condition is of course easy after death; but a diagnosis of non-fatal cases—that is, in the living child—is scarcely possible. It will probably produce convulsions and paralyses of irregular type, which, however, are quite likely to be ascribed to other causes. So long as diagnosis is impossible there can be no rational therapeutics. A most instructive case, however, is that of Tapret.[3] The skull of a new-born

[1] *Med.-Chir. Trans.*, 1875, vol. lviii. p. 183.
[2] *Zehender's klin. Monatsblätter*, 1878, 2te Beiträge.
[3] *Journ. de Méd. et de Chir.*, Avril, 1877.

infant was so deformed by passing though a narrowed pelvis that the left eye protruded; on this side the parietal bone was deeply depressed, broken, and pushed under the border of the frontal. The right side of the child was involved in convulsive motions, and the child was apparently beyond hope. Tapret incised over the depression, although the skull was rounded out by an external hæmatoma, corrected the position of the bone, after which the wound healed kindly, and the child was restored to health again. This is perhaps the only instance of its kind in literature.

In adults subdural hemorrhages are the not uncommon results of head-injuries, being usually accompaniments of lacerations of the cortical substance of the brain. They may result not only from rents in the small veins, but from openings in the large sinuses. The amount of the blood thus poured out is sometimes considerable and stretches over both hemispheres, or, if poured out in the upper part, it follows the laws of gravity and extends beneath the base of the brain. As this blood coagulates it forms a thin clot like a membrane, which may almost completely surround one or both hemispheres. If the patient survive the injury, this coagulum disappears very slowly by absorption, or it is known to leave more or less firm remains upon the inside of the dura, or to leave simply remains of its existence in the shape of extensive pigmentations.

According to Hutchinson, the bleeding in these cases takes place rather from numerous small vessels than from one large one, and hence is poured out with less compressive force, and ceases much short of the results which middle meningeal rupture can produce. A subdural clot is usually accompanied by more injury to the brain-substance. Spasm due to irritation of the motor area may be present; paralytic symptoms may be pronounced. Symptoms and signs do not vary much from those of extradural hemorrhage.

It is well established that these subdural hemorrhages may be the starting-points for pachymeningitis; it is also well established that pachymeningitis may follow injury in previously healthy individuals, even though resorption of blood has been apparently complete or nearly so. The most common results of this kind are disturbances of consciousness and mentality. Some of these patients gradually run down with paralytic dementia. When these subdural hemorrhages are extensive, they give sometimes a clinical picture corresponding closely to the extradural. Thus Goodhart[1] reports an instance in which the amount of clot was extensive and the patient rapidly succumbed. It was a four-year-old girl, who recovered from the first symptoms, but died fifteen days later, just after eating. The hemorrhage in this case had extended along the base to the medulla, from which it had slowly penetrated into the fourth ventricle, in which was found a fresh clot, which was undoubtedly the cause of speedy death. No fracture of the skull nor injury of the brain was found. Sudden death is not the usual termination in these cases, but they lead usually to mild pressure-symptoms, mental uncertainty, sleepiness, and slowing of the pulse. There may be certain automatic motions or posture-symptoms—as continuous holding of both hands up to the face, the drawing up of one limb, etc.—though

[1] *Guy's Hosp. Reports,* 1876, p. 131.

these are not common. At other times the usually conscious patient is very restless, difficult of restraint, and perhaps noisy and disturbant. This milder type of brain-pressure, which is apparently due for the most part to cortical irritation, may continue over several weeks. The first impulse in these cases perhaps is to endeavor to revive the patient to consciousness, but experience has shown that this is an unwise course to follow. While these patients live they are capable of resorbing even extensive clots, and the best treatment, so long as there is no distinctly surgical indications to follow, is that which may best support and sustain strength and circulation. They, as a rule, gradually recover from the long sleep, and even more suddenly regain their mental powers. Perhaps the most obstinate remaining signs or symptoms are headache and difficulty in mentality, loss of memory being one of the most common results.

In these cases one has naturally to distinguish between persistent coma and the numerous minute hemorrhages sometimes known as "disseminated capillary apoplexies." These minute ecchymoses constitute, of course, minute focal lesions; throughout a large part of the cortex they produce no distinct symptoms; only at certain points may they lead to disturbance of single functions—namely, in the so-called motor region, and possibly in the medulla. In most instances long duration of unconsciousness bespeaks a congestive disturbance; patients quickly relax into somnolence after being roused or they show sudden signs of irritability, such as jumping out of bed, crying out, grinding the teeth, or some paroxysmal muscular action. These attacks gradually subside in frequency and violence. The more active manifestations are to be ascribed to congestive influences; the more comatose the patient, the more positive and permanent the hemorrhagic lesion. Inasmuch as limited subdural hemorrhages produce no specific nor pathognomonic symptoms, no positive line of action can be laid down; in fact, they are often scarcely to be distinguished from those of contusion of the brain, and call, in fact, only for the same general treatment. These are cases which perfectly justify an aseptic exploration, in spite of the sneer with which Bergmann records the case already reported, as above mentioned, by Parker. This, which appears to Bergmann only an instance of sheer luck, will strike surgeons of to-day as an instance of remarkably clear judgment.

Finally, it may be added that it has been suggested to tie the common carotid, or perhaps its internal branch, in certain cases of ingravescent cerebral hemorrhages (apoplexies). For this course there would seem in selected cases sufficient ground, and the writer urges a trial of the same.[1]

[1] The following cases of this character may better illustrate this. They were reported by Dercum and Keen (*Journ. of Nerv. and Ment. Dis.*, Sept., 1894):

CASE I.—Patient of fifty, with apoplexy of progressive character and left hemiplegia. Remembering that Horsley in experimenting could control hemorrhage from the basal ganglia and corpuscles by ligating the common carotid, and that in consequence he had suggested ligation of this vessel as the treatment for cerebral hemorrhage in man, it was here proposed and accepted, and performed. The progressive course of the paralysis was evidently arrested thereby, and was continuously improved so long as it was kept under observation.

CASE II.—Middle-aged man, also with symptoms of ingravescent hemorrhage, in whom, while the preparations were making for similar ligation, the paralysis so rapidly

HEMORRHAGE INTO THE LATERAL VENTRICLE.

This might be distinguished as one variety of subdural hemorrhage, and the distinction would be of more importance could it be made clinically. In such instances, however, the individuality of symptoms is lost in the general comatose condition of the patient, and these cases are of interest pathologically rather than in any other way. In one or two instances, however, the presence of such clots has been suspected, and deliberate incision has been made into the ventricle for the purpose of their evacuation. The first such case on record was by Dennis, who diagnosed the presence of intraventricular clot in a case of traumatic hemorrhage with monoplegia, and who deliberately incised into it, with the result of permitting the escape of a clot which was pressed out to a considerable distance.[1]

A case similar to this I have reported in the *Medical News* for Dec. 3, 1892, and will briefly epitomize as follows: A man of forty fell from a height not exceeding five feet. Upon the morning following the injury he was walking about the house, but not talking. During the third night following the injury he became hemiplegic upon the right side, and next morning was comatose. Operation was undertaken as a last resort to see if brain-pressure could be relieved. A large 5 cm. trephine was applied low down over the left motor area, although the only external evidence of injury was a slight linear ecchymosis behind the opposite right ear. Even after exposing the bone no sign of fracture was revealed. Upon removal of the bone the dura appeared darker than natural. After opening it some laceration of the brain-cortex was discovered. The most striking feature was marked increase of intracranial pressure. After further exploration without discovery of satisfactory cause I passed the needle of an exploring syringe in the direction of the lateral ventricle. At the depth of 6 cm. I removed 12 or 15 c.c. of fluid blood with the syringe. I then passed a director down alongside the needle and removed 30 c.c. more of semifluid blood. After the operation the pressure was so reduced that the cortex subsided to its proper level and the man began to use his right arm. The ventricle was then drained. The patient lived only a few hours. On autopsy complete diastasis of the longitudinal suture was found, extending far down posteriorly and anteriorly, so that the halves of the skull were almost ready to fall apart. There was also a small fracture on the right side. Numerous other small clots were found, and in the left lateral ventricle, which had been already tapped, was found remaining a small, firm clot.[2]

deepened that unconsciousness had supervened before it could be performed. Artery tied at 10 P. M. without an anæsthetic. Patient, however, failed to rally, and survived but a few hours.

[1] Case reported by Keen, "Surgery of Lateral Ventricles," *Trans. of Internat. Med. Congress for 1890*, vol. iii. p. 109.

[2] In the *Philad. Med. News*, June 5, 1886, Formad terminated a medical-legal study of intracranial hemorrhage with conclusions, some of which may be of interest here:

Hemorrhage on the outside of the brain is always due to traumatism, provided that a cerebral source for hemorrhage is excluded and that the vessels and membranes are not diseased.

Hemorrhage in the floor of the fourth ventricle is always traumatic, provided there are no blood-clots in the lateral ventricles or in any parts of the congested cerebral substance. In the anæmic brain-substance a slight ventricular ecchymosis may indicate that death ensued from epileptiform convulsions.

Lacerations and Injuries of the Brain.

These may be divided into two groups—one in which the cranial bones themselves have been broken, and the other in which only the cerebral tissue itself is involved, or at least in which the bone does not participate save by some trifling fracture of the inner table. A recognition of the importance and character of these lesions was first made by Dupuytren. Since his time surgeons have striven to portray an accurate clinical picture of brain-contusion and to separate it from compression and concussion. Dupuytren himself taught that this was only possible after a few days; others, like Sanson, and Boinet his student, sought to constitute a new symptom-group which should be recognized at once. These views were accepted much earlier in France than in Germany or England. Up to the time when Griesinger divided these brain-lesions into the diffuse and the local or focal it was held that contusions of the brain in general produced clinical symptoms which followed a pretty typical course. It was this division which did much to clear up the subject. Later, it was shown clearly that brain-injuries of this kind produce lacerations, extravasations, disturbances of circulation, and later inflammatory lesions, and that it was difficult to include the results of all of these in any single clinical picture.

The appearance of the injured brain-substance will depend upon the degree and extent of the lesion: we may have minute local disturbances or lesions involving an entire hemisphere. The milder forms show at the point of tissue-injury a sprinkling of numerous dark hemorrhagic points, most numerous in the centre of the injured area, while the brain-tissue itself takes on a more or less diffuse red tint, fading out toward the periphery. The points are due to minute hemorrhages, the redness to the imbibition of bloody coloring-matter by the substance of the brain. In more extensive injuries we may find clots as large as peas imbedded in the substance of the brain, with an area of imbibition-redness around each of them. These clots may often be washed out with an irrigating stream, leaving well-defined cavities behind them. When blunt foreign bodies or fragments of bone have been driven into the brain, the tissue takes on a brownish-red color, while a mixture of tissue-fragments and blood-clots, containing perhaps hairs or fragments from the coverings of

Hemorrhage exclusively below the pia in the brain-substance or into the ventricles, except the fourth, is always idiopathic.

The blood-clot in concussion (contusion) of the normal brain is not found at the point of application of violence, but usually somewhere on the opposite side, and always between the pia and the dura. In rapidly-fatal cases of fracture there is usually a second intradural clot in some other part of the brain, due to contrecoup.

Blood-clot within the cranial vault is more favorable if due to fractured skull than if due to mere concussion (contusion).

Only clotted blood and infiltration of blood-corpuscles into the tissues indicate an ante-mortem hemorrhage. Exudation of coagulable blood indicates a post-mortem hemorrhage. Post-mortem oozing only stains, but does not infiltrate, tissues. In cases of instantaneous death the blood may remain liquid. Where rapid asphyxiation or certain poisons co-operate with the injury in causing speedy death the blood may also remain liquid and clots may fail to form.

Severe bruises and cuts may be seen in cases of idiopathic apoplexy where a sudden cerebral hemorrhage causes a person to fall.

The bulk of intracranial hemorrhage stands usually in direct proportion to the duration of time elapsed from the moment of injury to death; but it stands in inverse proportion to the bulk of external scalp hemorrhage.

the brain, and other foreign material, will be met with. The transition from the involved to the uninvolved tissue in these cases is always at first quite abrupt. Finally, in certain instances of great violence we may have absolute rupture of brain-tissue, the fissure extending from the cortex even perhaps into the ventricle. The more severe forms of brain-injury accompany compound fractures with depression and penetration of bone-fragments or of foreign bodies; the milder forms, especially the minute punctate hemorrhages, belong to the milder type of contusion. The more the elastic skull is compressed, the more significant are these appearances in the injured area. They are perhaps found most typically in those cases where the skull has been run over or compressed in some such way. It is undeniable and positive that contusions of this kind may occur without evident lesion of the bone. Astley Cooper and his followers long since settled this beyond question.

So far as the location of the injury is concerned, it will depend upon the nature of the lesion and the object which inflicts it. When the body which injures the skull is small—at least, when the applied surface is small—the contusion will usually be found in that part of the brain just under the site of the injury, or perhaps also exactly opposite to it; but in many other cases, especially when the surface involved is extensive, the principal tissue-disturbances will be found upon the other side of the brain. Thus, in severe injuries to the occipital region we may find the frontal or temporal lobes contused and lacerated; as, for instance, in injuries produced by falls from a height or by blows with a club or kicks from a horse the brain will show most injury at the point opposite to that where the bone is broken and depressed.

We have again here to allude to the importance of the cerebro-spinal fluid as a means by which many of the minute lesions found in these cases are produced. When, for instance, the direction of the violence is from before and above in a backward and downward direction, the fluid contents of the lateral ventricles are powerfully forced out, and immediately seek to escape through the Sylvian aqueduct. Inasmuch, however, as this fluid must find insufficient room in the fourth ventricle and the central canal of the cord—the lateral ventricles containing five or six times more than these cavities—their walls are materially distended, and must give way at one or more points, while from the injured vessels blood may escape into the nerve-substance. In consequence, one finds the brain-tissue around these cavities dotted with minute extravasations. A cross-section through the aqueduct, the fourth ventricle, and the upper part of the central canal will show these lesions very plainly (Plates VII. and VIII.).

Duret has even found perimedullary extravasations in the lumbar portions of the cord under these circumstances. It is often quite possible to burst the fourth ventricle by force upon the head, as Duret's experiments have shown, in one case the medulla being separated into halves as the result of excessive action thus produced. When we appreciate these facts, it is quite easy to understand how the evidences of violence, even when this is applied to the outside of the skull, may be very conspicuous in the neighborhood of the fourth ventricle and the medulla. This also will explain many of the phenomena which follow such injuries.

Lacerated wounds of the brain-material lie, almost without exception, in and about the convexity of the hemispheres, the exceptions being produced by foreign bodies penetrating from without. Lacerations in a narrower sense, however, are found for the most part in the depths of the brain or at its base, especially when the applied surface of the impinging object is large. In 36 fissures extending from the convexity of the skull to its base, along with lacerations of the brain, studied by Hewett, the brain-lesions themselves were found only 5 times in the upper part, and 31 times in the neighborhood of the base of the brain. Evidences of contusion are much less often found in the pons. In the post-mortem records of St. George's Hospital for sixteen years they were met with only four times. Boinet only records one case, and Falk in one case of depressed fracture of the convexity found a small hemorrhage in the middle of the pons. Contusions in the cerebellum are more frequent, and are met with almost entirely in its lower portion. Thus Hewett found here an extravasation the size of a hazelnut, and Blandin has found the entire cerebellum dotted with numerous capillary hemorrhages. So, too, in eleven cases reported by Hewett the cerebellum was that part of the brain most particularly involved. In the cerebellum Hewett has found the majority of these lesions in the neighborhood of the septum pellucidum, in the fornix, and in the thalamus.

The frequent occurrence of contusions of the brain-tissue along with intrameningeal hemorrhages is so conspicuous that it finds a place even in legal medicine. Very often the question has arisen whether it be probable that one in a drunken state falling to the ground have suffered from apoplexy or from the result of violence. Should a single fresh lesion in the interior of the brain present, the probability is that it is apoplectic, especially should there be evidences of degeneration in the cerebral arteries or in the heart. On the other hand, should the picture be rather one of contusion, it is much more likely to be of a truly traumatic character. Spontaneous capillary apoplexies are usually scattered over the brain, particularly in the cortical region. When there are several extensive hemorrhages in the brain there are almost always minute capillary hemorrhages between them. Of particular significance are minute ecchymoses in the medulla; even before Duret had announced his views upon cerebro-spinal shock Beck had remarked their frequency in his experiments concerning concussion. They seem, therefore, to be evidences of violence, and much less often of non-traumatic lesions.[1]

COURSE OF BRAIN-CONTUSIONS.

During the course of these injuries, as well as of lacerations of the brain, it obviously makes an immense difference whether suppurative processes complicate them or not. With reference to these, the first and most important factor by which infection may be excluded is that the integrity of the soft parts outside of the cranium should be preserved. Next to this, perhaps, come into play disturbances of the circulation, both inside and outside the cranium. It is well known that traumatic swellings under some circumstances assume very great dimensions, which

[1] Zeller, "Ein Fall von schwerer Hirncontusion ohne Schädelverletzung," *Deutches Zeitschft. f. Chir.*, xxxvii. 540.

are only limited by their environment. Slowing of the circulation, which is more or less marked in cases of contusion and laceration, is not such a very important factor, except as it may produce œdema of the brain in an indirect way. It will be remembered that lacerations of the brain are very frequently combined with intrameningeal hemorrhages. These, of course, will predispose to swelling of the injured region by pressure upon the veins. Extensive lacerations and hemorrhages may in this way produce swelling in dangerous degree, not merely in that they encroach upon and disturb neighboring regions of the brain, but that the quantity of cerebro-spinal fluid may be increased by extensive transudation, by which also the intracranial pressure is increased, perhaps even to a fatal extent.

Supposing this danger to be successfully passed, the next question is with regard to repair. It is well established that brain-lacerations may heal by cicatricial repair, the remains of the same corresponding very much to those of old apoplectic foci in the cortex. The most frequent result is a simple depression firmly united by the pia and dura, sometimes even with the bone, especially when the latter has been fractured. If this be examined, it will be found that we have a picture of sclerosis of nerve-tissue rather than of a fibrous cicatrix. In rare instances there will be found a spongy tissue beneath the membranes, more or less porous, in whose cavities is contained a yellowish fluid. This tissue will be surrounded with more or less sclerotic and cicatricial new formation. These correspond to the apoplectiform cysts which are found in the interior of the brain, only these are peculiar to the surface. A completely-formed cyst with brownish-red or chocolate contents is the result, usually, of deep and considerable hemorrhages into the cerebral tissue. A possible third result may be met with in the shape of yellow softening, due to disturbance of circulation in the cortex in the immediate neighborhood. The injured area conducts itself very much as would a conglomeration of punctate hemorrhages, which are known to terminate in red and yellow softening. The final result is a defect or loss of substance taking place beneath the pia, which is often indicated by a yellowish fatty emulsion; the borders of this area are tinted brownish-red. In some cases these changes show a tendency to progress toward the interior, which is usually favored by fatty degeneration of the vessels.

During the latter part of the present century considerable pains have been taken to ascertain experimentally the exact condition of repair inside of the brain and the methods by which it is carried out. Glüge began experimenting with needle punctures in the brain; since his day numerous investigators have varied the methods, but have arrived at pretty uniform results. It has been found that there is a striking analogy between repair of cerebral tissue and that of liver-tissue, as Bergmann has pointed out.[1] Other things have also been made plain; among them this—that even when cicatrization is proceeding there may occur a radiating degeneration of connective tissue through the brain, which may develop an interstitial encephalitis or a progressive yellow softening or gray degeneration of the same tissues. Kraft-Ebing has described changes of this kind occurring throughout the brain of an executed criminal who in his fourteenth year sustained a severe injury to the skull,

[1] *L. c.*, p. 423.

with adhesions between the cortex and the bone; the underlying hemisphere was permeated by cicatricial fibres, and its actual cerebral tissue reduced in volume by at least a third. Changes analogous to these have been described by Tillmanns, the same being in effect a traumatic cirrhosis. Progressive yellow softening is much more frequent than the changes just noted.

Another group of sequelæ of these injuries is constituted by cases which present evidence of secondary degeneration of nerve-fibres, as a result, apparently, of their laceration. These have been particularly well described by Charcot and Vulpian, who found them most often after cortical lesions, especially of the central convolutions.

Not less interest centres in the question of the possibility of regeneration of these same tissues. It is well known that in the nerves of the extremities a remarkable and functionally almost perfect regeneration of divided nerves may occur, the experiments and clinical experiments of Glück being especially instructive in this direction. It is largely through his experiments that the now well-established procedure of nerve-suture has been placed on a firm basis. Unfortunately, that which obtains in the peripheral nerves cannot be depended upon within the brain. Demme[1] is perhaps the only writer who claims to have seen a real regeneration of primary nerve-fibres in the brain. Our present position in this matter, based upon general experience, must be to the effect that a defect in the human brain is, to an almost complete extent, irreparable.

Another question of great interest is with reference to the encapsulation or inhealing of foreign bodies. Some years ago Bruns came to the conclusion that a permanent healing of a patient who had a bullet in the brain was a rare exception, and that scarcely a single patient remained well who had suffered this injury. Of 73 cases of perforating gunshot wounds of the skull noted during our Civil War, 14 survived. But this bare statement is by no means sufficient to indicate their real condition. Of these 14, 12 suffered from severe later affections of the brain, for the most part headache, vertigo, and disturbance of special functions; 2 were blind, 7 weak of sight, 1 dumb, 1 hemiplegic, 1 paraplegic, and 3 suffered from various localized paralyses; only 1 of the entire number appeared to be really well. Andrews[2] gathered 73 cases of gunshot wounds, including Brun's cases, in which recovery had followed after gunshot wound of the skull. In 6 of these the ball had compromised the bone, but not the dura; 7 others must be thrown out for various reasons; of the remaining 60, 23 patients died of the later results of these injuries—*i. e.* 9 of brain-abscess, others from meningitis, thrombosis, or pyæmia, 6 of causes not recorded, and 9 from causes not connected with the brain. Only in 2 cases out of the entire number could one justly claim a permanent recovery from the injury. Of interest in this connection is Neudoerfer's[3] relation of a case in which a bullet was spontaneously extruded from the interior of the cranium a long time after the injury through a fistulous passage of the lateral region of the skull which had remained open for three years. Equally rare and interesting are the disappearances of the bullet, which gradually sinks or makes its way toward the base of the brain, as Flourens has observed in animals. The

[1] *Kriegschirurg. Studien*, 1863, vol. i. p. 67. [2] *Penn. Hosp. Rep.*, 1868, p. 281.
[3] *Handbuch Kriegschir.*, vol. i. p. 41.

rare instances in which this thing has occurred in men seem to be limited to cases where the original perforation was in the frontal region.

Penetrating wounds of the brain do not differ in any essential respect from those already considered. The wound-canal usually terminates in a blind extremity, although points of knife-blades or other foreign bodies may remain in the depths of the wound. The brain may be penetrated in this way through the cavities of the orbit and the nose, and small substances introduced through these channels may give rise to fatal meningitis. The only external evidence of such injury may be a slight ecchymosis of an upper or lower eyelid, and yet, as Holmes has related,[1] through this apparently trifling wound a bayonet may have penetrated and its broken point remain within the brain. In *St. Bartholomew's Hospital Reports*[2] is given the history of a boy whose orbit was penetrated by a fragment of glass, which was removed under chloroform. Two months later he died with symptoms of meningitis. On section the arachnoid corresponding to this area of the skull was found infiltrated with pus, with another fragment of glass an inch long imbedded in the anterior lobe. That such cases as these pursue a most insidious and misleading course has been well illustrated by numerous published case-histories.[3] See, for instance, Down's case.[4] Such cases as above alluded to completely establish the doctrine, which ought always to be taught, that in every perforating wound of the brain or its membranes there is always danger of a fatal meningitis sooner or later. A case of great rarity is that reported by Simon.[5] In the brain of a woman aged seventy-nine there was accidentally found, on autopsy, a needle which had penetrated the entire left hemisphere; in the sagittal suture there was a little depression, but no defect which corresponded to the protrusion of the inner table. The eye of this needle was near the surface; its point lay in a lateral ventricle. It seemed probable to the reporter that this had been introduced during the infancy of the individual, being pressed through an open fontanelle in a homicidal attempt. Such cases, at least, are known to the medical jurists. A still more remarkable case is that reported by Huppert,[6] who in an autopsy on a middle-aged man who had died with epileptic seizures found imbedded in the depths of the brain a three-inch-long slate-pencil. There were no markings on the dura or brain which would indicate from which point this had penetrated, and it is considered that it must have been introduced during his early childhood. So too Hodge[7] discovered on autopsy of a male patient a sewing needle, with its point directed posteriorly, sticking in the right hemisphere, parallel to the longitudinal sinus, an inch away from it. In this case the individual during life had shown no symptoms of cerebral lesion.

Symptoms and Diagnosis of Cerebral Injuries.—Diagnosis is based upon two circumstances: first, that by any injury to the skull either cerebral concussion or disturbance of circulation can be produced; and,

[1] *Treatise on Surgery.* [2] 1876, vol. xii., Appendix, p. 42.

[3] *Vide* also Fischer, "Ein Ladestock im Gehirn. Heilung.," *Deutsche Zeitschft. f. Chirurgie*, xviii. p. 411.

[4] *Am. Journ. Med. Sci.*, 1871, p. 139.

[5] *Horn's Vierteljahresschrift f. Gerichtliche Medicin*, 1869, S. 193.

[6] *Wagner's Arch. f. Heilkunde*, 1875, p. 97. [7] *Phila. Med. Times*, 1877, p. 526.

second, that the symptoms of brain-contusion are practically those of a more or less localized brain-lesion. While the former influences the circulation of the entire brain, the latter affects it in only more or less limited areas. The anatomical lesions met with in brain-contusion entitle it to be considered as allied rather to brain-compression than to brain-concussion. One asks first in these cases whether the injury has determined disturbances which affect all parts of the brain alike, or whether there may not be discovered signs or symptoms indicating partial disturbance of particular areas or functions. The determination of the questions thus raised is usually not difficult. In effect, the symptoms of contusion are somewhat intermediate as between those of the other conditions so often mentioned. These partake more of the nature of one or the other in proportion to the extent of the lesions which determine them. Any localizing symptom or sign is *ipso facto* equivalent to a diagnosis at least of brain-contusion. Without these such diagnosis cannot be made; with them the element of brain-shock alone is not sufficient to account for the discovery. Until a comparatively recent time a diagnosis of contusion was based rather on what could be found by inspection of the injured area. During the last decade or two, since the physiologists have taught us so much about localization of functions, the diagnosis can be made even without examination of the wound itself, although this of course lends valuable assistance. As concerning the matter of localization, there has been so much said elsewhere with regard to location of tumors in the brain that the reader must be referred to what has been there stated, since it would be quite superfluous to repeat the observations made in that place. If one only holds that all injuries, at least to the cortex, will determine symptoms of some kind, and especially in that part of the cortex known as the motor area, he is not likely to go far astray, providing that the anatomy and physiology of the brain are familiar to him.

There are, however, certain things to be added to what has been already said; for instance, that a contracture or paralysis following injury after several hours or two or three days is to be ascribed to a meningeal complication. This will include a long list of convulsive and paralytic phenomena which have been described by many authors. These phenomena may occur even several weeks after injury. In the somewhat classical case quoted by Broca in his memoir the first disturbance of this kind set in on the thirty-second day after injury, and the patient died on the following day. Take also the case reported by Landouzy: A young soldier received several sabre-blows upon the left side of the head, of which two penetrated, while a ball broke the right temporal bone. There were no marked symptoms until the second day, when fever and spasms of the limbs on the left side set in. On the fifth day there was left hemiplegia, and he died upon the sixth. The cortex of the right side in the motor area was thickly infiltrated with pus.

One other point in the diagnosis of genuine contusion must be clearly established: the paralyses which occur in this way must not be accompanied by other evidences of compression; in other words, there must be lacking in these cases the deep coma, the snoring respiration, the altered pulse, etc. which are the conspicuous evidences of classical compression, since should such present it might be an indication of menin-

geal hemorrhage, which of course means compression, the latter condition being the graver, obscuring the minor condition of brain-laceration or minute hemorrhages, which might also occur in connection with the same injury. In other words, for diagnosis of contusion we must not meet with conspicuous evidences of compression. Perhaps it can be best summed up in these words: Cases which are not evidently those of concussion, and certainly not of distinct compression, deserve to be considered cases of contusion. Some help may be afforded by the location of the injury. Thus, the further removed the point of the injury from that part of the brain evidently affected, the more likely is it that we have a case of contusion. In the literature of the army surgeons a number of cases have figured where some time after head-injury there have been atactic or paraplegic symptoms which have been ascribed to undetermined causes. Thus, for example, in the military history of our own war there is related a case of contusion of the frontal bone, followed by spinal irritation and, later, paresis of both lower extremities. It is quite possible in the light of our present knowledge to explain these cases by what is known to occur within the brain without suspecting the spinal cord.[1]

Quite a common later result consists of a combination of paralyses with contracture of the limbs involved. In fully one-third of these cases there is also disturbance of sensibility as well as of motion, this consisting quite commonly of motor paralysis, anæsthesia, analgesia, and loss of muscular sense.

So far as injuries to the base of the brain are concerned, there has been very much progress made within the last twenty years, by which more accurate diagnosis and appreciation of pathological conditions are afforded. These have come partly through Hewett's emphatic statements with regard to the prevalence of contusions of the brain in cases of basal fracture, and partly through Duret's teachings concerning cerebro-spinal shock and the occurrence of minute ecchymoses in the walls of the fourth ventricle and adjoining tissue. Certain anatomical conditions also come into play here, particularly the peculiar arrangement of the vascular distribution at the base of the brain, which differs from that of the convexity. Upon the upper cerebral surface there is much greater freedom of collateral circulation than at the base, since, when an internal artery in the latter location is torn across, a certain area of brain-substance is completely shut off from the possibility of nutrition.

Of importance is it also in the matter of diagnosis that certain combinations of paralyses and lesions of distinctive nerves should be properly studied. Here one must be particularly careful. Take the case, for instance, of so-called "bulbar" paralysis, in which it is not yet made out positively whether it takes its origin from contusions of the medulla or from involvement of the nuclei in a diffuse neuritis. Many of these complicated paralyses are much easier to explain upon the hypothesis of a periostitis somewhere about the base of the skull than as genuine intracranial lesions. A case has been reported by Vix of hemiplegia and hemianæsthesia as a result of unilateral injury of the medulla, which Erb is inclined to regard as a unilateral division of the uppermost part of the spinal cord just below the decussation of the pyramids.

[1] See Bergmann, pp. 458 et seq.

One must remember also the result in experiments on blood-extravasations in the medulla, where Cheyne-Stokes respiration has been repeatedly observed; then he will be often tempted to ascribe to medullary injury the lesion causing these phenomena in certain head-injuries. The coincidence also of disturbances of respiration with albuminuria, or of disturbances of sensation in the upper part of the body, reminds one of the same results, since these as a purely spinal symptom may be produced by extension of blood-infiltration along the posterior portion of the cervical cord.

Not a little importance is attached in many of these cases to the appearance of glycosuria and albuminuria together. It is well known that by puncture in the fourth ventricle Claude Bernard could influence the secretion of urine. When this puncture was made between the origins of the vagus and the auditory nerves, he found mellituria as the result. When he punctured below this point, he got only simple polyuria; and, finally, when the puncture was made above it, there was no increase in the quantity of urine, but it contained albumin. It is not infrequently the experience of the surgeon that after a fall or blow upon the head, especially upon the occiput, sugar is found in the urine, or that the patient will develop an extreme thirst, or that perhaps albumin will be discovered. Even in 1783, Pouteaux[1] remarked the large quantity of fluid which one of his injured patients called for; and Larrey remarked that after a punctured wound which reached from the right eye into the floor of the left lateral ventricle he found sugar in the urine. Goolden[2] estimated that out of 225 cases of head-injury diabetes occurred in 5.7 per cent. Nevertheless, Griesinger insists that in twenty cases of traumatic diabetes studied by him no alterations could be found in the walls of the fourth ventricle. The complication of paralyses of those cerebral nerves whose nuclei are found in the medulla with diabetes is a clinical coincidence of great importance occasionally met with. It must be acknowledged, however, that diabetes follows not only head-injuries, but other traumatisms, particularly injuries of the lower abdominal organs. Fisher, for instance, got together not less than twenty-two such cases.

Another important class of lesions following head-injuries are those of the lungs, and particularly of two forms—broncho-pneumonia and hemorrhagic or œdematous infiltration—which may proceed even to hepatization of perhaps the lower lobes while the upper remain œdematous. The pneumonias which occur in this way remind one of those produced by bilateral division of the pneumogastrics. Some of them are produced by paralysis of the glottis, the result of which is incomplete closure and the aspiration of fluids and solids from the mouth, whose decomposition sets up an infectious inflammation assuming this type. Calmeil determined that out of 188 cases of inflammatory brain-disturbance pneumonia was observed in 66 instances, and Engel has emphasized that the majority of apoplectic patients die of some form of hypostatic pneumonia. It was Brown-Séquard who first determined that after lesions of the pons, with or without coincident diabetes, hemorrhages took place in the lungs. Others have shown that these also follow lesions of the basal ganglia or even of the cortex. The connec-

[1] *Œuvres posthumes*, vol. ii. p. 123.

[2] *Lancet*, 1854, vol. i. p. 657.

tion between such hemorrhages and the other disturbances just alluded to will be at once seen. Of all the theories held to account for hyperæmia, œdema, and inflammation of the lungs, Bergmann regards that as most plausible which supposes a paralysis of the pneumogastrics, by which pernicious influences are made felt both in the heart and in the vessels of the lungs.

Particular parts of the base of the brain have been injured in peculiar injuries. Thus, Pamard[1] relates that an actor in a mimic theatrical combat received a puncture through the orbit which determined an immediate left hemiplegia. Autopsy showed that almost the entire right cerebral peduncle was transfixed. Bergmann has shown that in cases where patients have manifested a peculiar halting gait with feeling of vertigo there has been fracture of the labyrinth, and that the sense of weight or of co-ordination has been more or less disturbed.

Treatment of Fresh Brain-injuries.—Of these we may say, perhaps more than of any other injuries to the human body, that the safety of the patient depends upon the treatment first received at the hands of the attendant. If this be careful and aseptic, such cases may be kept free from almost all complication; if otherwise, the result in all probability will be the patient's death. Here, then, above all other regions, is it necessary to carry out an absolute and thorough primary disinfection. This is not the place to point out how this should be done, but only to insist upon the thoroughness of the action. After this be attended to one may hold with Bergmann that the next most dangerous complication is the remaining in the wound of some splinter which may not have been removed, but which ought to be sought for by the aid of trephining. Any foreign body should be removed with absolute care when possible; and it is not only proper, but life-saving, to go to any justifiable length in order, first, to determine the presence of such, and then seek to remove it. This practically sums up the treatment of brain-injuries so far as they themselves are concerned, providing, of course, that the ordinary canons of wound-treatment are here observed, these consisting of checking hemorrhage and such approximation of wounds or such provision for drainage as the circumstances of the case most demand.[2]

Traumatic Inflammation of the Membranes.

LEPTOMENINGITIS SUPPURATIVA.

A primary meningitis develops itself practically only as a result of a perforating injury of the skull. It is, aside from hemorrhage or some gross lesion, the thing most to be dreaded in such injuries and in compound fractures. Secondary meningitis occurs under varying and variable conditions. First, it may be caused by the extension of venous thrombi, which extend into a sinus from the dura without: whether these thrombi undergo suppuration or decomposition, there is a direct

[1] *Gaz. hébd.*, 1865, p. 455.

[2] Kocher, "Chirurgische Beiträge zur Physiol. des Gehirns und Rückenmarks," *Deutsche Zeitschft. f. Chirurgie.* xxxv. 433, and xxxvi. 1; also, Ginger, "Zur Casuistik der Kopfverletzungen," *ibid.*, xxvi. 217.

path of infection to the membranes themselves. Secondly, meningitis may be the result of a neighboring periostitis or ostitis of the cranial bones, and this may occur either as the result of thromboses which are occurring in the diploëtic veins, or the continuous path of infection may be even more direct, and the infectious products from the bone may come into immediate contact with the structures beneath. Thirdly, such infection may occur by continuity along the nerve-sheaths at the base of the brain, and be quite analogous to the meningitis produced from middle-ear disease. Thus, it is well known that panophthalmitis may lead to fatal meningitis, and Martini has reported the spreading of suppuration along the auditory nerve even to the basilar artery. Bergmann has reported the same thing along the facial nerve. Finally, meningitis may be the result of a traumatic brain-abscess, either superficial or deep.

Primary meningitis sets in sometimes very early, even within twenty-four or thirty-six hours after the injury. The most powerful factor in these cases is the access of air containing germs of decomposition, since a suppurative meningitis (traumatic) with absolutely undivided soft parts and without fracture is practically out of the question. Numerous factors predispose to or favor the development of meningitis in these cases, particularly the size of the wound through which the dura is exposed, and next to this the pressure which may be exerted by the products of wound-infection and the obstruction which may be offered to their free escape. Since the pia particularly possesses a stratum of loose rich œdematous connective tissue, there is nothing to prevent traumatic inflammation of this membrane assuming an even phlegmonous type, which may pursue the same rapid and disastrous course here as elsewhere in the body; one feature of which, of course, is purulent exudate, which will be found particularly not upon the free surface of the arachnoid, but in the parenchyma of the pia itself. Here, as in other connective tissue, pus follows the vessels, particularly the veins, and the more violent the process and the longer it lasts, the more the veins will be involved, while the membrane itself will become thicker and harder and more separable from the underlying cortex. When the process is of comparatively slight intensity the membrane becomes less opaque.

From the beginning the cerebro-spinal fluid is made cloudy and contains numerous flocculi, which give it a peculiar appearance. Doubtless its amount within the ventricles and the subarachnoid space is increased, and it becomes more and more mixed with purulent and fibrinous débris.

Traumatic meningitis is always most marked at the point of injury, and sometimes remains more or less limited about this point. When it extends to the base, however, it reaches a high degree of violence, and may even extend down the spinal canal and perhaps along the sheaths of the spinal nerves. Bergmann relates that in at least three instances he has seen a spinal meningitis follow a head-injury where its anatomical lesions were visible down so far as the cauda equina.

Clinically, we may divide these cases into those which appear some time after head-injury—perhaps several days—and those which even from the beginning present signs of meningeal infection and disturbance. Or we may group them again into those where the lesions apparently

remain confined to the convexity, and those which present signs of basilar meningitis.

When the disease is fairly limited to the convexity and the patient passes several days without signs of the disease, it begins usually with chills and malaise, with increasing temperature, after which the symptoms soon assume a pyæmic type, from which, however, it perhaps may be distinguished by the fact that pyæmia, as such, seldom develops until after the end of the first week, whereas meningitis may set in on the third or fourth day. Pyæmia, too, is more likely to be accompanied by frequent chills. In these meningeal cases the pulse becomes more frequent, at first full and then small; the patients become disturbed and restless, sometimes almost uncontrollable, complain of headache, cry or moan, grate the teeth, make sometimes frantic efforts to get out of bed, and finally become quite delirious and in every respect uncontrollable; the face becomes red; the eyes glisten. After a while a period of quiet succeeds the restlessness; the delirium subsides into stupor or into deep sleep; the pupils are narrowed, and remain without reaction to light; sometimes the pupil upon the injured side becomes dilated, and in some of these cases ophthalmoscopic examination will show a commencing neuritis. A meningitis in these cases may also be distinguished from pyæmia by the occurrence of clonic spasms of certain muscles or by paralytic phenomena. In many of these instances it will be possible by symptoms present to localize more or less accurately the site of the disturbance.

In those cases where the patient is from the beginning unconscious, and remains so for a long time, we lack many of the indicative manifestations of meningitis; nevertheless, paralyses or cramps coming on after two or three days should make us watchful, and the temperature should be closely scanned for such indications as it may afford. It is known that resorption of intracranial hemorrhages seems to be accompanied by a certain degree of temperature elevation, perhaps up to 39° C. When the temperature rises much above this, meningeal complications should be suspected.

Traumatic basilar meningitis occurs most often with fissures of the base. Its symptomatology is not so significant as that of meningitis of the convexity, since we are less likely to have the distinctive paralyses and signs of congestion. When, however, in these cases the pulse becomes smaller and the temperature quickly rises, we should regard these as signs of extra importance, and may look for signs of involvement of certain of the cranial nerves; as, for instance, the facial or the auditory. Sometimes there are paralyses of others, like the ocular motor or abducens, whose origins or exits from the skull are thus involved. Thus, should there be ptosis, dilatation of the pupils, paralysis of the tongue, loss of pharyngeal sensibility, etc., we should be quick to suspect extension of meningitis along the base of the brain. One of the most significant signs of all in these cases is cramp or stiffness of the cervical muscles, which has long been held distinctive also in cases of tubercular basilar meningitis. Although this sign is accurately due, probably, to involvement of the upper part of the cervical cord, it simply means extension of a condition which is already very grave, and the sign is to be looked for in all these cases. Indeed, this sign is of sufficient value

to justify diagnosis even in the absence of other phenomena. Finally, it is said that the sudden occurrence of albumin in the urine and increase of phosphates are very likely to happen in these cases, and it is always worth while to make the examination. The existence of previous conditions negativing this evidence should, however, if possible, be eliminated.

The **prognosis** of purulent meningitis is the worst possible. The length of time during which this disease may last can only be approximatively prophesied: the majority of cases do not last over three days, although some of them are known to extend over even two weeks; in a general way we may say from three to five days.

Treatment seems to be almost absolutely futile, it being vastly better to take measures by which this condition may be prevented than to endeavor to treat it when too late. One, of course, should make the endeavor by energetic purgation, possibly with venesection and the immediate administration of mercurials, to do what he can. The only thing which probably offers any prospect is a reopening of the wound or a fresh trephining for the purpose of irrigation and drainage. In such case should there be suspicion of cortical abscess, it will of course add nothing to the danger to make proper exploration with the aspirating needle.

In a memorable paper by S. W. Gross[1] are the following words, true now as they were over twenty years ago: "The treatment of compression of the brain from effusion of pus is purely surgical; and all authors are unanimous in the opinion that, unless the matter be evacuated, the patient will die, although they are equally agreed that this measure holds out but little chance for life."

The bulk of the paper is a powerful plea for that which seems to be now seldom practised—*i. e.* the same treatment of a suppurating dural cavity that we are now most ready to carry out when other serous sacs are converted into abscess-cavities. We do not hesitate now to open and wash out the joints, the peritoneum, the pleura, nor even the pericardium, under these circumstances; then why not the dura, even though this necessitate more than one trephine opening? Of 11 cases collected by Gross, all more than twenty-five years ago, 5 (*i. e.* 45 per cent.) recovered.

Traumatic Brain-abscess.

We distinguish between acute and chronic abscess as the result of head-injuries. Among the former, acute suppurations, which occur more or less in the depth of a contused or injured brain, may occur during the first few days after injury, and may run a course combined with meningitis or independent of it, except as they may terminate by it. The ordinary form of acute cerebral abscess of traumatic origin occurs, however, within the first two weeks after an open injury to the brain, and commonly in the shape of an acute cortical abscess. It lies under a more or less compromised membrane, in volume sometimes of considerable size, is surrounded by a zone of red softening, and this by another of brain-œdema; its pus contains considerable free fat and detritus. When one studies a large number of brain-injuries which have terminated during the first ten days or so, he receives the impression that in lace-

[1] *Am. Journ. Med. Sci.*, vol. lxvi., 1873, July, p. 57.

rated wounds of the convexity meningitis is the most frequent cause of death, while with contusions at greater depth it is more likely to be acute softening and œdema, which produce death. If, however, the case escape a diffuse meningitis, and if pus may find exit through an open wound, there is a possibility of spontaneous recovery; granulations may be formed from the surrounding tissue which take the ordinary course and finally cicatrize.

Quite distinct clinically are the chronic traumatic abscesses. These are less often cortical, but more commonly are met with in the depths of the brain. Their etiology is not so simple. Clinically, they are usually marked by a prolonged suppuration affecting the wound, and it may be that the periosteum is also involved. Another class of these chronic abscesses has yet another origin. Bergmann, for instance, reports the case of a middle-aged man who had suffered for a long time from a retropharyngeal abscess which broke into the pharynx and left a fistulous track which constantly discharged pus. In his case autopsy revealed disease of the basal portions of the skull and of the occipito-atloid joint; the right transverse sinus was filled with an infected clot; from this sinus two involved veins led into an abscess-cavity in the right occipital lobe. In many other instances in which the history of trauma is more or less prominent abscesses have occurred in peculiar ways or in peculiar localities.[1] In the *N. Y. Med. Journ.* (1875, vol. i.) is a report of a total rhinoplastic operation where the integument from the forehead had been employed; after seven days convulsions set in, and death followed on the eighth. There was found an abscess near the lateral ventricle, and the longitudinal sinus was filled with thrombi. Meyer has reported five other more or less similar cases. Multiplicity of abscesses has also been frequently noted.

The following case well illustrates this matter of multiple lesions: It occurred in a lady approaching elderly life, from whose upper nasal passage on one side a polyp was removed by my colleague, Dr. Hinkel of Buffalo. At first she did well, but later rather severe nasal symptoms presented themselves, and at the expiration of about four weeks she developed brain-symptoms and became unconscious. In this comatose condition there were no localizing symptoms whatever, and it was from inference, rather than from any safer guide, that we decided to explore the frontal lobe. Accordingly, without an anæsthetic, I raised a frontal flap, and made a good-sized trephine-opening about 2.5 cm. above the orbit on the side from which the polyp had been removed. After opening the dura, which appeared normal, I used the needle of an exploring syringe and passed it in in several directions, once quite through the falx and 3 cm. into the other hemisphere, searching for pus. Upon the fourth or fifth attempt this was found directly back of the trephine-opening and at a depth of about 3 cm. The abscess-cavity was then freely opened and 12 c. c. of fresh pus were evacuated. The cavity was drained with rubber tubing and the wound closed and dressed. The patient never recovered consciousness, but died the following day. Examination was fortunately permitted, and it was found that on the other side, in almost exactly the corresponding locality, was a similar collection of pus of about the same amount. The point of my needle

[1] See Bergmann, *l. c.*, p. 510.

must have gone within a very short distance of it, although it was completely missed.

It is only the chronic abscesses which show encapsulation, this being entirely lacking in the acute. This capsule is often more or less of the character of the *pyophylactic* membrane which the writer has elsewhere[1] alluded to as deserving *this* designation, and not the old name of pyogenic membrane. The chronic abscesses may extend over long periods of time; in one case in my own practice this was nine years, and Gerhardt and others have mentioned twenty and more. Pus from these has a more or less greenish color and acid reaction; while ordinarily without odor, it is sometimes extremely fetid, especially when in the neighborhood of the ear or when produced by necrosis of bone.

For the **symptoms** and **diagnosis** of brain-abscess, acute and chronic, the reader is referred to the section on Infectious Processes in the Brain.

Prolapsus (or Hernia) Cerebri.

Lacerated wounds of the brain in connection with compound and gunshot fractures frequently give rise to the escape of brain-matter from the external wound. This may escape with the blood at the time of the accident or it may present itself during the ensuing days. It is more likely to occur when the skull has been injured by a dull, large perforating object. In these cases, as one washes and cleanses the wound, he observes brain-matter in the hair, in the blood-clot, perhaps in the provisional wound-dressing which may have been applied as an emergency dressing. Escape of the brain from its proper cavity, which occurs during the first few days after the injury, has been called by the English surgeons "hernia cerebri"—a term which Bergmann criticises, since the term "hernia" would imply some protrusion occurring beneath the skin. This subcutaneous protrusion is seldom met with, and he would suggest the term "prolapsus cerebri" as a more accurate substitute. This protrusion may vary in size from a small tumor to one the size of a fist. It is determined, of course, by an increased intracranial pressure, either as the result of serous imbibition or as the result of brain-abscess. When the latter is present, it will be found in the immediate neighborhood of the protruded part. Prolapse of this variety appears always by degrees, increases in size, and, as a rule, finally completely fills the opening through which it escapes. Its growth is not rapid at first; after a little it increases very slowly, and then comes to a complete standstill. As a rule, these protrusions occur through small openings, such as those made by gunshot wounds, etc. It is rare when we have a hernial protrusion through a large cranial defect, although Hewett has seen such a case after complete separation of the frontal bone. The existence of a prolapse of this kind implies necessarily a laceration of the dura, which is one reason why it has been occasionally met with after the ordinary operations for trephining in which the dura has been incised. Of 43 hernias, so called, of this character, mentioned in the history of our Civil War, 25 occurred after removal of pieces of bone, and 4 after trephining. In deliberate operations it has followed

[1] *The Mütter Lectures on Surg. Pathology* (by Roswell Park, etc.), St. Louis, 1892, p. 62.

as a sequel, especially in those cases where abscess has been suspected, but not discovered, in which it occurs as the result of a continually increasing intracranial pressure.

Those lesions which permit prolapse occur, almost without exception, on the convexity of the skull. The diagnosis, however, has been made by discovery of the escape of brain-matter along with pus from the ear. It does not follow, then, that every discharge from the ear in these cases is necessarily purulent. Billroth saw in one case of head-injury that discharge from the ear was occurring, mixed with blood, which looked as if it might be either pus or brain-material. With the microscope, however, it was found to contain only epithelial débris and concerned only the external ear. Hawkins is quoted by Hewett as having to do with a boy who had been shot through the right malar bone, the bullet entering the brain. On the seventh day, having been free from symptoms in the mean time, he became delirious, and then unconscious. Brain-material escaped from the external wound, where there developed a tumor of considerable size. The patient died after thirty hours, and there was found the track of the bullet beneath the orbit into the sphenoid, whose great wing had been injured, through which canal the brain-material had escaped to the outside. Holmes also has mentioned a prolapse of the brain into the orbit, the greater part of the anterior convolution being concerned. A large amount of brain-material may escape in some of these cases. Baum[1] has mentioned a case of brain-prolapse where on the eleventh day clear blood, evidently that from the ventricle, began to escape. Probably the majority of cases of this kind are fatal, death being finally caused by extending inflammation, especially by leptomeningitis suppurativa. The mortality-rate, however, is smaller in the modern aseptic era than it was a generation or so ago.

In a general way, the **prognosis** of later prolapse or of so-called hernia cerebri is unfavorable. There is always risk in these cases of œdematous swelling or inflammation, either of which may proceed to gangrene. Pirogoff observed that during the Crimean War all cases of gunshot wound were followed by prolapsus cerebri. Demme observed, in the Italian War of 1859, 5 recoveries out of 21 cases. Of the 43 cases mentioned in our own Civil War, only 7 recovered.

These protrusions of the brain are rarely, if ever, covered with dura, since a defect in this membrane is the essential characteristic of their formation. That part which presents externally may have appearances akin to those of normal brain, or these may be very much modified, both color and consistence varying greatly and depending in no small degree upon the amount of vascular obstruction, also upon the length of time which has elapsed since its occurrence. Infiltrations, gangrenous sloughs, suppurations here and there, or granulations, both disfigure and disguise the real brain-substance.

It does not follow that every tumor which presents through an opening in the skull is necessarily of this character. Hemorrhages from the pia with escape of blood-clot through a small laceration of the dura, after further modification of the same by external environment, may be mistaken for prolapsus cerebri. Such clots, containing perhaps tissue-shreds, may receive a sort of covering from the external parts, or in

[1] *Centralblatt f. Chir.*, 1877, p. 841.

certain instances have been found covered with mould or with adventitious material which completely masks their real nature. There are also tumors which consist of granulation tissue, in which proliferation is rapid, which may spring from the dura, or possibly from the bone itself, and which, presenting externally, may be mistaken again for genuine prolapsus cerebri. Schmidt[1] has reported such a case: A boy of four who fell upon a nail sustained a wound of the skull, which cicatrized, but later broke open, and presented a livid pulsating tumor surrounded abruptly by the bone, the tumor being about the size of a walnut. After death it was found that this tumor consisted of extremely vascular connective tissue which had its origin in the dura. Underneath it lay a large abscess involving the entire frontal and part of the temporal lobe.

Extensive protrusions of this character frequently undergo gangrene; the necrotic part becomes dark, smells badly, and is often in the highest degree offensive. Unpleasantly and unfavorably as this process would be generally regarded, it is not particularly dangerous, for it is often followed by cicatrization and healing. After separation of the dead part the stump becomes covered with granulations, recedes, and is finally roofed over by connective tissue, which affords very perfect protection. Sometimes, however, this later protection fails, and patients are left with a granulating tumor of this character.

Special **treatment** for prolapsus cerebri is out of the question. In recent cases absolute cleanliness and aseptic dressings are the best protection; the later forms of hernia cerebri need to be treated in such a way that both brain-congestion and meningitis shall be avoided. This can perhaps best be done by antiseptic dressings and energetic application of cold. Localized pressure does good in some cases; in others it cannot be borne. Signs of abscess should be watched for, and exploration of the underlying brain-tissue is often justifiable or plainly indicated. Excision, cauterization, and ligation are generally held to be dangerous, although one reads of occasional success after these procedures. Some cases have been provided with protection in the shape of shields made of caoutchouc, celluloid, or metal, which have had to be worn for varying lengths of time. Skin-transplantation has also been successfully practised in order to assist in the process of cicatricial protection.

Injuries of the Cranial Nerves in Connection with Traumatic Lesions of the Cranium.

OLFACTORY NERVE.

Injury of the olfactory bulb by gunshot, with loss of sense of smell, was perhaps first described by Jobert. The ball perforated the right orbit and went through the root of the nose; the patient died of encephalitis and the ethmoid was found shattered. Other somewhat similar cases have since been recorded by numerous surgeons. The occurrence of anosmia after injury to the skull of other character is of no little surgical interest. The first note of this condition was made by Ogle.[2]

[1] *Bayerisches Intelligenzblatt*, 1866, No. 2.
[2] *Med.-Chir. Trans.*, 1870, vol. liii. p. 263.

Later, Knight[1] collected 22 cases of this kind. In 10 of them there had been the ordinary symptoms of basal fracture, among which four times the occiput was involved, twice the ear, and once each the temporal and frontal region. In the other 12 instances, in 6 the blow was received upon the occiput, and in 2 upon the side of the head; details were lacking in the other cases.

Furthermore, the function of the olfactory bulb may be interfered with in other ways, as, for instance, by infiltration of blood along the sheath of the nerve through the pores of the lamina cribrosa. In these cases the loss of function is not permanent. Thus, Brodie has recorded the resumption of function after one year. The instances recorded by a number of authors thus show that an isolated loss of smell may happen after head-injuries, not so much necessarily as a paralysis, but as a disturbance of function from which recovery may follow. Of course it may be combined with injuries and disturbances of function of other nerves or organs. It does not necessarily follow, however, that loss of smell is due to injury of the olfactory bulb, since Hewett has recorded a mistaken diagnosis where, owing partly to facial paralysis and partly to dislocation of the septum, the left nostril was completely closed, its dilating muscle being paralyzed, and in which, of course, smell on this side seemed to be destroyed.

INJURIES OF THE SECOND PAIR.

The optic nerve can be injured anywhere between its origin and its entrance into the sclerotic. Lawson[2] records a division of the nerve by a knife-blade. By violence applied from without the nerve has been torn from the globe, as reported in several instances. Foreign bodies have also been imbedded in the nerve, which have caused not only atrophy of that eye, but sympathetic disturbance in the other, and have necessitated extirpation. Leber divides the injuries of the optic nerve into those which occur posteriorly to the entrance into its trunk of the central vessels and those which occur anteriorly to it. In cases of the first group the ophthalmoscopic picture may be normal, at least for some time, only changing after a number of weeks as the papilla undergoes white atrophy. In the second group the changes produce results much resembling those of embolism of the central artery; the distinction between arteries and veins is lost. If after a few days the vessels can fill themselves again, the veins appear hyperæmic.

Of the 88 basal fractures studied by Holder, the optic canal was found compromised in 54, and in 42 of these 54 the optic sheath was found more or less filled with blood. Just how this blood gained entrance here—whether through the fissure of the bone and the optic sheath, or whether by hemorrhage from the intrinsic vessels of the nerve—is not completely set forth. The great frequency of fissures involving the optic foramen, and the still greater frequency of optic lesions after serious injuries to the head, afford an important indication in the study of these cases. It is also known that fragments of bone splintered off from the optic canal may injure the nerve. Such cases have been reported by Larrey, Gemuseus, and others. Phillips recog-

[1] *Boston Med. Journ.*, Sept. 13, 1877. [2] *Lancet*, 1875, i. p. 13.

nized this condition during an autopsy: a piece of iron had penetrated into the left orbit and detached a piece of bone from the ethmoid, and this had divided the optic nerve.[1] In ophthalmological literature other cases, more or less corresponding to those hinted at above, may be found detailed at length.

INJURIES OF THE OTHER OCULAR NERVES.

The oculo-motor, or third, nerve may be injured—at least some of its branches may—during the act of parturition by the pressure of obstetric forceps, as Nadaud[2] has twice seen. This paralysis was unilateral and disappeared in a few days. In the celebrated tamping-iron case—a specimen of which is now in the Harvard Museum—the oculo-motor nerve was divided. So in a case of fracture of the orbital roof Selwyn found the nerve torn. So, too, in the case of Gemuseus, spoken of above, the orbit had been penetrated by one blade of a pair of scissors, with paralysis of the oculo-motor and other motor muscles of the eye. Paralysis of the oculo-motor has also been observed as the result of severe head-injuries in which the cerebral symptoms have lasted for a long time. The explanation for this has not been forthcoming at the autopsy, but the clinical fact is certain.

Paralysis of the trochlear nerve after head-injury has been much less seldom observed. Bergmann reports one case: A thirty-seven-year-old man, falling from the third story of a house upon the pavement, broke several bones, had a wound of the forehead with all the appearances of brain-concussion, and bled violently from the nose. He lay for fourteen days before recovering consciousness. In the fifth week he complained of double vision; at the end of ten weeks it was evident that the diplopia bade fair to be permanent. In this case the peculiar protrusion assumed by the left eye made it evident that the superior oblique was paralyzed. Somewhat similar cases have been recorded by Wharton Jones and by Herb.

Although the abducens runs in a fissure along the so-often fractured petrous bone, a rupture of the nerve-trunk has never been noticed in autopsies save once: A forty-year-old man fell from a height, striking upon his feet, sustaining symptoms of mild concussion. Three weeks later the abducens was paralyzed; four months later a furious delirium developed, and he died. Upon autopsy both clinoid processes were found broken from their bases, and through the upper third of the right petrous bone there was a transverse fracture with loosening of a small stick of bone. It was just here that the trunk of the sixth nerve was torn.[3]

After basal fractures involvement of this nerve has been frequently observed, although the exact character of the lesion has not been made out. The abducens is also paralyzed in many cases of pulsating exophthalmos. Billroth[4] and Leared[5] have recorded cases of paralysis of the sixth and seventh nerves on the same side. It is easy to see how

[1] *London Med. Gaz.*, Jan., 1841.
[2] *Les Paralysies obstetricales des Nouveau-nés*, Paris, 1872.
[3] Quoted by Aran, *Arch. gén.*, 1844, vol. iv. p. 191.
[4] *Chirurg. klinik.*, Wien, 1871–76, p. 75.
[5] *Lancet*, March, 1869.

they might both be involved in a basal lesion, the origin of the two nerves being very close together. Both origins might also be involved in an infiltration or suppuration in their neighborhood.

INJURIES OF THE FIFTH NERVE.

An isolated division of the fifth nerve at the base of the skull has not yet been positively made out at autopsy, although more than one case has pointed clinically toward such an injury. Rigler[1] relates that he saw a Turk of twenty-five who eight months previously had received a kick from a horse upon the left side of the head, who was unconscious for several hours, then suffered from stupor, headache, and a corneal affection, and that half a year later he had complete anæsthesia of the regions supplied by the fifth, as well as loss of taste in the anterior two-thirds of the same side of the tongue; there was also evidence of previous corneal ulceration. Involvements of the fifth nerve are more frequently observed in connection with lesions of the other cranial nerves. Thus, Hulke[2] saw in one case, after a blow upon the head, bleeding from the ear, an escape of serous fluid for a long time, along with protrusion of the eye, loss of sight, and other disturbances of special function, these disturbances lasting for weeks and bidding fair to be permanent. Anæsthesia of the trigeminal area after head-injuries appears always to lead to a neuro-paralytic lesion of the eye, as has been many times observed. Emminghaus voices the opinion that in many cases of unilateral atrophy of the face there has been a lesion of the trigeminal at its entrance into the ganglion as the result of injury in the neighborhood of the petro-basilar synchondrosis.[3]

INJURIES OF THE SEVENTH AND EIGHTH PAIRS.

The facial nerve has often been injured by the obstetric forceps during parturition, but these injuries are almost invariably followed by speedy resumption of function. The nerve has been injured at its exit from the skull by gunshot, by the horn of a cow, by the hoof of a horse, by the lancet of a charlatan, and in various other ways.[4]

In basal fractures the nerve, either alone or with the auditory nerve, has been paralyzed in numerous instances. In 24 fractures of the base of the skull in the Hamburg Krankenhaus, which were studied by Leisrink, 5 times the facial was found to be paralyzed, and once both the facial and auditory.[5] Of 49 cases collected by Schwartz, in 14 there was paralysis of the facial, and in 5 of these of both nerves. It is quite exceptional when the lesion is bilateral. Bergmann could only find 2 cases of traumatic diplegia of these nerves—1 recorded by Davaine, the other by Ketli. It is rather curious that when this nerve is so often involved there should be so few instances of discoverable lesion of its trunk recorded in post-mortem reports. Those reported have been very few, one of the best of them being that by Bell, who in a longitudinal fracture of the petrous bone found the nerve torn across at its entrance

[1] Romberg, *Nervenkrankheiten*, 3d ed., p. 362.
[2] *Med. Times*, 1869, vol. ii. p. 240.
[3] *Deutsches Arch. f. klin. Med.*, vol. xi. p. 96.
[4] See Bergmann, p. 404.
[5] *Arch. f. klin. Chir.*, vol. xiv. p. 55.

into that bone. When the facial is torn across—as may easily happen during its tortuous passage through the petrous bone—the paralysis will be noticed immediately after the injury, and will probably remain permanent. When improvement or recovery follows it is unmistakable evidence that the nerve was not divided. In these cases we may suppose that it has been infiltrated with blood or has been pressed upon by coagulum in the Fallopian canal, as, in fact, it was found to be in one instance by Prescott Hewett. In one case, recorded by Adams,[1] both nerves were paralyzed at first, but the facial recovered its function.

To those cases where the facial paralysis does not appear at once there is a peculiar significance attached. Here we have to deal with a genuine ascending neuritis, as is evidenced by swelling, injection, and softening of the nerve-trunk. Of the 6 cases out of the 24 studied by Leisrink, mentioned above, this kind of degeneration occurred in 3. Very often it coincides with serous discharge from the ear, but not necessarily so. In these cases the inflammatory process travels along the fissure, reaches the nerve, attacks its sheath, and the above results follow. There is every reason in these cases to fear the accession of a basilar meningitis, which is the actual cause of death in so many fractures. In some cases the degenerative process can be recognized as travelling along the different trunks, as its results appear perhaps first in the mouth, and during the following days in the other regions supplied by branches of this nerve. Hutchinson[2] has reported three clinical histories where between the third and fourth days paralysis of the facial set in, and was followed by fatal basilar meningitis. The peculiar function of the chorda tympani may be studied in some of these cases of injury, and according to the presence or absence of the sense of taste some deductions may be drawn as to the exact point in the bone where the nerve has been injured. If along with the facial paralysis the auditory nerve-function is also lost, one may appreciate at once that there has been a transverse fracture of the petrous in the neighborhood of the posterior wall of the middle ear. If the auditory nerve is not paralyzed, the fissure is probably longitudinal; if there be any involvement of the auditory nerve, the internal meatus has probably been compromised. A lesion of the chorda tympani alone, without paralysis of the other branches of this nerve, has been diagnosed in at least one case by Brunner.[3] In this case the upper part of the membrana tympani appeared thickened and the bony wall of the tympanum in its neighborhood seemed to be distorted.

Disturbances of the auditory nerve have a much more exact significance in cases of basal fracture than those of the facial. Hemorrhages into the labyrinth, as well as a filling of the middle ear with extravasation, may of course occur without fracture of the petrous bone. The first would absolutely paralyze the function of hearing on that side; the latter would at least seriously affect it. When we have absolute deafness in one ear, with facial paralysis as well, without paralysis of taste on that side, we hold that both nerves have been injured in the neighborhood of the internal meatus. The former is less often made out than the latter. A direct injury of the labyrinth is also possible by penetration of long,

[1] *N. Y. Med. Rec.*, 1874, June 1. [2] *Med. Times*, 1875 vol. ii. p. 61.
[3] *Archiv für Ohrenheilkunde*, v. 32.

small foreign bodies from the external ear. A case is recorded in the *Gaz. des Hôp.*, 1857, No. 130, where a needle had been forced into the labyrinth in this way from without.

INJURIES OF THE OTHER CRANIAL NERVES.

One instance is recorded by Pirogoff[1] of an isolated lesion of the glosso-pharyngeal: A soldier suffered a contusion in the back of the neck; in time his speech became affected and deglutition was made impossible. The papillæ at the root of the tongue ulcerated. He died one night of acute œdema of the glottis. On autopsy there was found in the course of the glosso-pharyngeal nerve a small tumor, which was discovered to be an encapsulated clot of blood.

In the Musée Dupuytren there is a skull in which the line of fracture involves the anterior condyloid foramen in such a way that there must have been laceration of the hypoglossal. Clinical history, however, does not go with the specimen. In many cases of hemiplegia after head-injury, as well as in those due to apoplexies, the patients are able to protrude the tongue, but only toward one side. These are cases, probably, of central disturbance, and not lesions of the nerves themselves.

Morton[2] reports the case of a man suffering from severe basal fracture who had at the end of the first week a paralysis of the first and seventh nerves, and probably also of the ninth. He died in ninety-one days, and there was found in the left hemisphere a brain-abscess, while all the nerves passing through the oval, round, sphenoidal, optic, and stylo-mastoid foramina were involved in the softening and more or less degenerated. This case illustrates one cause of secondary paralyses occurring after head-injuries.

Septic Infections within the Cranium.

Under the above caption it is proposed to include abscess, thrombosis (the marasmic thrombi being included for convenience), sinus-phlebitis, and meningitis, these being in effect only varying manifestations of essentially the same pathological conditions, differing according to the tissues and localities affected.[3]

It will be well, probably, to begin by a brief catalogue of the bacteria which are most apt to be met with in the acute cases. These are, first of all, here as elsewhere, the varieties of staphylococcus, of which the aureus and albus are the most common; then the streptococci, the writer holding that the streptococcus of erysipelas is really indistinguishable from the streptococcus pyogenes. Next to these we must mention the diplococcus pneumoniæ of Fränkel,[4] and the bacillus pyocyaneus, whose

[1] *Kriegschir.*, p. 197.

[2] *Phila. Med. Times*, 1874, No. 153.

[3] The writer must acknowledge his large indebtedness, in the preparation of this section, to the monographs of Macewen (*Pyogenic Infectious Disease of the Brain and Spinal Cord*, 1893) and Forselles (*Ueber Lateralsinus-thrombose*, 1894), from which he has appropriated not a little.

[4] Nauwerck (*Beiträge zur Pathologie des Gehirns.*, Leipzig, 1881) gives an extensive and comprehensive summary of a case of suppuraitve meningitis consecutive to croupous pneumonia, and quotes Brach to the effect that 15 cases of meningitis were noted in 11,442 of pneumonia, while in Basle the percentage of these cases was as high as $\frac{3}{10}$. He believes in forming a classification of meningitis pneumonica.

well-known characteristic it is to impart a greenish or bluish tint to pus and even to the surrounding tissue. This color is due to a substance capable of separation; and it is further of interest to remember that, during November of 1893, Bouchard stated in Paris that he had isolated from cultures of this organism two toxins, having peculiar and opposite activities upon the vasomotor system, which he named "ectasine" and "anectasine." The former has the property of dilating the vessels; the latter, of contracting them. This statement has a clinical value when we remember that some cases of septic infection are complicated by peculiar eruptions, some of which simulate scarlatina or the other exanthemata. These capillary dilatations are supposed to be produced by the ectasine to which Bouchard has alluded. I have repeatedly seen green pus issue from intracranial abscesses, but do not recall in any of my own cases the appearance of this septic eruption.

Some years ago Passet isolated what he called the "bacillus pyogenes fœtidus," and upon experimenting with it found that injections of it would produce suppuration. At least seven years ago, before I had more definite information about this organism, I discovered that one case of cerebral abscess under my own care contained pus which was a pure culture of this organism. More recently it has been established that this is the well-known colon bacillus masquerading under a longer name. This seems to be now clearly established, and we must therefore modify the statement, so that it shall read that the colon bacillus is one of the agents which may determine suppuration within the cranium. Within a few years Neumann has described a bacillus meningitidis purulenta, which he claims to have met with only in cases of meningitis. But there appears to follow some doubt whether this is not really the colon bacillus, and whether those cerebral abscesses in which it is claimed that Eberth's typhoid bacillus has been found were not also due to the same cause. In these abscesses produced by the colon bacillus we meet with pus having an offensive odor, and it is not necessary to invoke the hypothesis of a mixed infection in order to account for the odor. On the other hand, in certain abscesses secondary to ear disease we are quite likely to meet with pus containing a mixture of pyogenic and saprophytic organisms, where we can properly claim that the infection is a mixed one. In abscesses of a tubercular nature we are quite likely to find the tubercle bacilli, although these may have died out long previously; and it is stated that in suppurating frontal sinuses, with some of the brain- and other abscesses which follow, we find also the staphylococcus salivarius pyogenes of Biondi.

Böttcher has reported one case of cerebral abscess following abscess in the lung in which lung-pigment was found in the pus of the former. There are also two cases reported of cerebral abscesses produced by oïdium albicans, which was transferred from the mouth and pharynx to the brain, the multiple abscesses of one case being filled with this organism.[1]

Salvages and Rivière have very recently reported a cerebral abscess in which they discovered a streptothrix. Patient was a man of thirty-two, under the care of Vergely of Bordeaux, without disease of ear or nose. Tuberculous meningitis was diagnosed. On autopsy there was

[1] Reported by Wagner, *Jahrb. f. Kinderheilk.*, vol. i. p. 56.

found a large abscess in the prefrontal region filled with greenish pus. Cultures showed the branched filaments of streptothrix. This parasite differs from actinomyces by the absence of grains in the pus, by the delicacy of the mycelium, which has no tendency to form masses, and by its abundance in the purulent foci.

Beck has reported a rare case of metastatic brain-actinomycosis, the primary lesion being in the pleura and ribs. Three years after the operation on the latter there were symptoms of parietal abscess, which was opened and emptied, recovery following. A year later another abscess formed; this was again operated and evacuated. Death occurred from meningitis. A tabular presentation of these cases will be found in Beck's article.[1]

In abscesses connected with the middle ear we may find leptothrix and other organisms, whose presence is perhaps more or less accidental, and to which we must not ascribe too much importance.

These are the organisms principally met with in intracranial infections, although it never need surprise one to hear of some other as an occasional inhabitant of the cranium.

Path of Infection.—The path of infection for micro-organisms from without may lie along the blood-vessels, the lymph-vessels, the nerve-sheaths, or the prolongations of the membranous sacs which surround the brain and which extend outside of the cranial cavity proper. First of all, and outside of these, however, there is free communication around the cranial cavity of all the cavities which contain air, and which have to do with the senses of smell and hearing, and there is free communication also between the orbital cavity and the brain-box within. The infection which begins in the nose, for instance, may spread both to the ear by means of the nasopharynx and to the frontal and ethmoid sinuses by means of equally well-known anatomical channels. When the middle ear has become more or less filled up with granulation tissue, and the membranous curtain protecting it from without has been destroyed, it forms a most favoring site for development of micro-organisms. So, too, when infection has once travelled up the infundibulum into the frontal sinuses, it finds there a closed incubating chamber in which increase of organisms may go on at a rate not to be appreciated from without.[2] Here, as in the mastoid cells, these processes are so far removed from the possible influence of parasiticide agents that they are not to be interrupted by ordinary measures. The well-known extension of the subdural and subarachnoid spaces along the optic nerve will explain cases of septic intracranial infection from phlegmons of the orbit or destructive suppuration within the ocular globe. These, then, are some of the principal paths of infection.

It would be quite superfluous here to try to catalogue the numerous venous communications between the scalp and the soft parts outside the cranium proper and the contents of the latter. Suffice it to say that cellulitis and thrombosis from without find an easy propagation by vas-

[1] *Beiträge zur klin. Chir.*, xii. pp. 1 et seq.

[2] For the possibility of brain-abscess and meningitis resulting from dental caries see the writings of W. D. Miller—*e. g. The Micro-organisms of the Human Mouth,* and a paper, "The Bacterio-pathology of the Human Mouth," *Philad. Med. News,* Dec. 8, 1894, p. 641.

cular continuity to the membranes, or even to the brain itself, and that nothing can be simpler than the explanation of a suppurative pachymeningitis consecutive to erysipelas of the scalp. Three years ago it was made my duty to trephine a frontal bone, for suspected abscesses in the frontal lobe, in the case of a lady who had developed serious brain-symptoms after an operation upon the nose, and who, when I saw her, was comatose. The operation was undertaken as a forlorn hope, and after two or three attempts to find pus with the aspirating needle a collection was discovered at the depth of an inch or so, not far from the crista galli. This was opened and drained, but without relief. Upon autopsy a day or two later it was discovered that there was an almost similar collection upon the other side of the falx cerebri which I had not discovered, although my needle had passed through the falx and must have gone into close proximity to it. This was an illustration of infection proceeding from the nasal cavity, and at that time was considered something of a curiosity, since then but few such cases were on record, and it had not been so clearly established that there is free lymphatic communication between the nose and the brain, and that such abscesses constitute a possible source of danger after intranasal operations. This case also illustrated the well-known possibility of multiple abscess-formation, and the clinical improbability of a recognition and complete evacuation of each of the collections of pus.

As Macewen has shown, if the inflammatory process be slow we may have localized involvement of the dura with extradural abscess, and, should this condition persist, an adhesive inflammation spreading to the inner side of the dura, resulting in adhesion with the arachnoid, and even the pia, by virtue of which a general leptomeningitis is guarded against in the same way as a general pleurisy is prevented from following abscess in the lung—by an adhesive inflammation which attaches the two layers of the pleura, and permits sometimes spontaneous or operative external evacuation of the abscess. Another probable result of this adhesive inflammation may be degeneration of the underlying tissues, with resultant subdural abscess, or such deeper disintegration of the brain-tissue proper as to produce abscess in the brain. When, however, these adhesions fail or when the infection is widespread, we may get invasion of the whole subdural space and a general leptomeningitis. Again, leptomeningitis and abscess may be the result of thrombotic and embolic processes alone, being then secondary to some disturbance of similar nature elsewhere. Sometimes this is brought about by reversal of the blood-stream, since the sinuses and intracranial and intraosseous veins are destitute of valves, so that when a thrombus has once passed within a sinus it may extend or be conveyed into the veins of the brain proper. The veins running into the sinuses about the petrous bone are very numerous and come from all directions, both from the brain itself and from the parts belonging to the ear proper. The importance of the perivascular sheaths of the arteries must also not be overlooked, since by them infection may sometimes rapidly travel. In fact, it is perhaps oftener along the perivascular sheath that infection is carried to the brain proper than in any other way. Thrombosis may sometimes be extensive, involving even the internal carotid artery, since complete oc-

clusion of this vessel following infection of the tympanum has been noted by more than one observer.

We have also numerous traumatic conditions which predispose to infection. Among these there must be mentioned punctured wounds penetrating into the bone. Here infective thrombosis occurs in the diploëtic vessels, to extend later along the perivascular sheaths into the brain. Free escape of pus being impeded by tough membranes like the pericranium or galea, deep extension is thereby favored. Punctured fractures are extremely liable to permit the introduction of infective material, not only into the bone, but perhaps even into the brain itself. Some of the most typical brain-abscesses that I have ever seen have been the result of infection thus permitted. These wounds are the more dangerous often because of their relatively trifling extent, which permits them to be overlooked. Compound fractures with extensive wounds are perhaps less liable to lead to trouble than those last mentioned, for the reason that they usually receive more prompt and careful attention. Here, however, when the canons of cleanliness and rigid asepsis have not been observed we are quite likely to find later the consequences of such neglect. Even from contusions and injuries which have not produced fracture we are quite likely to get external abscesses, which may communicate their infection to the parts beneath the bone along the channels already mentioned, or which may produce the same effect indirectly by causing first a necrosis of one table or the entire thickness of some portion of the skull. Here we have first extradural abscess, followed later by general infection.

The most common, however, of the paths of infection is afforded by the middle ear, deaths from septic infection of the cranial contents from this cause being probably more numerous than those from all others combined. When an acute inflammatory process affects the middle ear, it is much less likely to spread to the interior of the skull, because of the previously healthy condition of the mucous membrane, which, when quickly filled up with the exudate produced by the acute process, affords a barrier which micro-organisms seldom pass. Thus, even when diphtheria has spread to the middle ear along the Eustachian tube, we seldom, if ever, hear of a diphtheritic meningitis. It is a fact, then, that most of the ear-affections which produce intracranial disease belong to the clinically chronic class. It must not be forgotten that we may have an extensive purulent disease of the tympanum without external discharge or those signs which commonly lead to its recognition. The cases where we most frequently meet with deep infection are those where the membrana tympani have been more or less destroyed, when granulation-masses not merely fill the tympanic cavity, but project into its various adnexes, and when the mastoid antrum is enlarged by the destruction of the partitions between the mastoid cells. Under these circumstances, when the tympanum is actually enlarged, yet with its capacity diminished, we are very likely to get extension of infection which shall assume the clinical type either of thrombosis or of cerebral abscess. Let us remember also that in young children the various parts of the temporal bone are not yet united, and that consequently secretions or disease-products more easily find their way within the cranium or beneath the periosteum of the mastoid.

Just as in other parts of the body we may have an acute suppurative and infectious periostitis or infections of a much more tardy type, so we may have them here about the mastoid, where an acute periostitis with the rapid formation of pus may be met with, though it is relatively rare.

Abscess of the Brain.

Pathology.—It is not accident alone which determines whether the abscess resulting from middle-ear disease shall be found in the cerebrum or in the cerebellum. Tympanic caries is not an equally diffused affection. When the roof of the tympanum is most involved it ulcerates, and perforation occurs here, and then, naturally, the middle fossa of the skull is infected. It is possible to have extensive destruction of the whole interior of the petrous bone, only the very hard osseous tissues, like the cochlea and semicircular canals, resisting. This is usually a tubercular process, and has been found involving both sides. In fact, there has been found in a few cases a continuous tubercular process from one tympanum to the other through the petrous bones, the basi-sphenoid and basi-occipital. Tubercular meningitis usually concludes such a case as this. If the process be a pyogenic one, then we are likely to have a suppurative leptomeningitis, involving first the small ganglia and cerebellum, or the same may be the result of transmission of infection along the sheaths of the facial and auditory nerves. Most frequently we meet with perforation in the roof of the tympanum posteriorly into the antrum or into the sigmoid groove. In the former case we get temporo-sphenoidal abscess, in the latter cerebellar abscess, when these form at all. Previous to actual ulceration there is thinning of bone, and often thrombosis along the minute veins connected with the sinuses. The bone is also discolored—sometimes black, sometimes of a deep greenish hue. Macewen thinks that this discoloration is due to some pigment resulting from the growth of the bacillus pyocyaneus.

The dura which has been exposed by disintegration of bone granulates freely, and this granulation tissue serves as a protection often against further inroads, but, unfortunately, also assists in absorption of disintegrating bone. These masses may project into the tympanum, and have been mistaken for polyps. Their removal has been followed by serious and even fatal intracranial mischief. Similar masses project from the wall of the sigmoid sinus into the mastoid cells, where they are usually surrounded with pus which connects with the interior and forms essentially an extradural abscess. There is almost always thickening of the dura at such points as those above spoken of. Within the dura there is frequently adhesion of the pia mater, and thus the veins and lymphatics of the pia become directly involved with processes going on without the dura. This infection may spread along the perivascular sheaths to the interior of the brain, and this probably explains why cerebral abscess is more common in the white substance than in the cortex.

When the sigmoid groove is the seat of the early disturbance, an extradural abscess may form between the sinus and the bone at this point —supposing it to exist—and then the granulating process can scarcely fail to involve the inner aspect of the same channel. The consequence

is thrombosis in the sinus—a local sinus-phlebitis—thickening of the sinus-walls, and further softening or destruction of the same, by which infection within the dura is permitted. When such a sinus is opened, of course no blood escapes, the centre of the thrombus usually corresponding to an opening through the mastoid. By a retrograde process the cerebellar veins now become affected, and soon by thrombotic extension infection of the cerebellum takes place. This may result also, with less delay and less indirectness, by direct extension through the dura. Only exceptionally does infection travel backward from the middle ear through the internal ear, and so along the nerve-sheaths to the cerebellum, and when it does so travel it is much more apt to give rise to leptomeningitis than to abscess. When the aqueduct of Fallopius is opened infection may travel either along the facial toward the cerebellum or upward and forward along the great petrosal nerves. Macewen, therefore, is most wise in advising the observance of great caution in the removal of granulation tissue from the middle ear, since such removal is only partial and incomplete, and by it the natural barrier is taken away.

When there has been adhesion between the dura and the pia we may get actual brain-ulceration by molecular disintegration without the formation of a genuine cerebral abscess. Under these circumstances pus commonly escapes to the outer side of the dura through the perforation, and, if this be over a disintegrated tympanic roof, of course into the middle ear.

When once infection has passed along the perivascular sheaths into the substance of the brain, there is more or less rapid purulent disintegration, which will at first be superficial, the resulting pyoid products being confined between the adherent membranes and the brain itself. This will be a true subpial abscess. On the other hand, the formation of true cerebral abscess is simply a matter of further extension, and the disintegration of true cerebral tissue along the vessels which penetrate to the white substance. The consequence is a purulent encephalitis, which more or less quickly determines the formation of an abscess. Macewen insists that in the treatment of such cases it is most important not merely to evacuate the abscess, but to eradicate the path of infection from the point of origin. This, of course, is not always easy. The greater frequency of abscess on the right side is to be explained by the greater size of the lateral and sigmoid sinuses on this side, by their greater encroachment upon the petrous and mastoid portions of the bone, and by the reduction of distance between the cavities contained within this bone and the sinuses themselves. The initial aural disease shows no preference, but by virtue of these anatomical conditions its destructive results are more common on the right than on the left side. Extradural pus may escape into the mastoid cells through erosion of the inner walls of the cells into the sigmoid groove. Such escape of pus means practically an extradural abscess. Sometimes this pus escapes suddenly, and mental symptoms are, perhaps, thereby suddenly relieved. Even abscess of the brain itself may find an exit by destruction produced by ulceration of the bony confining walls. This of course is rare, but is known. In very young infants tubercular disease of the middle ear is quite apt to perforate the unossified portions of the temporal and produce tubercular meningitis. These cases, or those in which such a thing is likely, will be found com-

plicated by tubercular lymph-nodes in the upper region of the neck. In infants, too, the aqueduct of Fallopius is imperfectly ossified, and consequently much more exposed to infection. Consequently, too, facial paralysis occurs much more easily in them, and pyogenic infection spreads more easily along the nerve-sheaths to the base of the brain. Another possibility of the presence of granulation tissue in the tympanum is general extension along the Eustachian tube and the production of gravitation-abscesses in the nasopharynx.[1] This is the explanation of some retropharyngeal abscesses. So, too, pus may perforate and accumulate about the temporo-maxillary joint and cause erosion of the capsule. Pus from the mastoid cells also may escape along the digastric groove and form deep cervical abscesses, as Macewen's atlas beautifully shows.[2]

Once given an acute infection in the lowest tissue of the arachnoid, and we have very speedy involvement of the whole subdural and subarachnoidal spaces. The sheaths of the nerves are likewise involved, and the so-called water-bed upon which the brain is commonly supposed to float becomes now rather a bed of sero-purulent fluid. Here bacteria spread with great rapidity, all the conditions for their rapid growth being fulfilled. Leptomeningitis, therefore, under these circumstances becomes diffuse, most acute, and most fatal. Serous fluid may accumulate so quickly as to produce death by pressure upon the cerebral blood-vessels. We get also distention of the ventricles and acute infectious internal hydrocephalus in some of these cases. These are among the cases which are so often disappointing on casual post-mortem inspection, since appearances seem to fail to explain the fatal result. When the leptomeningitis assumes the quickly purulent type, there is great exudation into the perivascular spaces, inordinate dilatation of veins, the production of exudation, at first confined to the clefts and spaces of the surface of the brain, but later spreading wherever anatomical paths can carry it. Under these circumstances it may reach even the cauda equina, and possibly be continued along its nerve-sheaths. Such purulent forms usually produce encephalitis as well, and we have often to do with minute extravasations in the substance of the brain-tissue. Around these minute hemorrhages we frequently get areas of red softening—*i. e.* of escape of red corpuscles into the perivascular spaces, and consequent staining of the softened tissues. This is to be distinguished from white softening, in which there is very little of the hemorrhagic element, but means practically the rapid infiltration of the infected tissue with phagocytes, and the death of these and of tissue-cells, with the equivalent production of pus.

The pus contained within cerebral abscesses is sometimes much discolored by hemorrhagic extravasations, but when free from blood-coloring matter is frequently of a greenish-yellow tint, being probably stained by the bacillus pyocyaneus. It is sometimes thin and serous, and is then usually very fetid, the fetor often corresponding with that perceived from

[1] In 1862, Sanpasson demonstrated a communication between a cerebral abscess and a longitudinal fracture of the Eustachian tube, the case having but one parallel in that reported by Barr, where pus found its way along the base of the skull to the petrous portion of the temporal, and escaped from the roof of the external auditory canal.

[2] Macewen, *Atlas of Head Sections*, 1893.

pus in the middle ear, and being due to the bacillus pyogenes fœtidus—*i. e.* the colon bacillus. Around such an abscess is a zone of actively-inflamed cerebral tissue; projecting into its cavity are often portions of sloughs or shreds of sloughing tissue, its outline being very irregular. Sometimes rapid erosion of a vessel takes place, and we have an apoplexy into the abscess-cavity. Did this zone of encephalitis always involve parts of the brain whose functions are known, one might much oftener localize these abscesses than is now possible. When the active process subsides this area of tissue gradually condenses, and active infiltration of leucocytes occurs, with more or less organization, and, as a consequence, these collections of pus become encapsulated, the surrounding membrane becoming thicker and tougher as the months go by. The vitality of this membrane is very low, and it deserves the name which I would always give to such membranes of "pyophylactic."[1] Should it become complete, the abscess may remain practically stationary. Something akin to absorption is even possible under these circumstances: the fluid contents of the abscess become gradually absorbed, pressure from without seeming to facilitate it; gradually the pyophylactic membrane becomes more vascularized, and phagocytic action serves to dispose of its contained débris. On the other hand, should this capsule become replaced by vigorous granulation tissue, the size of the abscess may be augmented from within and the capsule finally burst. In this way such abscesses burst into either the ventricles or the subdural space, in which case acute symptoms come on most rapidly. Rare instances are known of spontaneous evacuation of such abscesses lying over the tympanum by obliteration of intervening tissues and final spontaneous disintegration. So, too, frontal abscesses have emptied themselves through the perforated cribriform plate into the nose.[2]

Meningitis and brain-lesions do not always follow the lesions of the bony structures in the wall of the ear—the dura, being so tough and fibrous, often prevents them for a long time; and a number of cases have been known *where the tegmen tympani was congenitally absent, and yet no bone-lesions have followed chronic otorrhœa.* Perforation, however, is not necessary to extend the disease to brain-membrane and brain-substance. Of 169 cases of intracranial disease investigated by Allport, only 98 were recorded as abscess proper.

Although many brain-abscesses are connected with the tympanum by fistulous openings through its roof, it is noteworthy that the main abscess-cavity is not usually located immediately above the diseased tympanum, else there would be strong indication here for evacuating it through this part of the bone. McBride thinks that if the auditory nerve is involved, as shown by a lack of bone-conduction, the abscess will probably be found behind the tentorium. Barker's view, that cerebral abscesses are

[1] *Vide* the writer's *Mütter Lectures on Surg. Path.*, 1892, p. 62.

[2] Allport (*Journ. Am. Med. Ass'n*, Oct. to Dec., 1892) has collected the data of 169 cases of brain-lesions following middle-ear disease, which are reported on in brief. Relative frequency shows 86 males, 40 females; sex not noted, 37. Also right ear, 81 cases; left ear, 69; ear not stated, 19. Quotes Barr's observation that the deaths in London in one year from brain-abscess following ear disease were 86, and in eight of the principal towns in Scotland, 26. Barker considers 50 per cent. of all cases of brain-abscess to be due to ear disease; Myer and Ogle place it at 30 per cent. Out of 128 cases, the ear affection was found to be acute in 10 and chronic in 118.

always found near the petrous bone, cannot be substantiated. Körner holds that children under ten years seldom suffer from cerebral abscess, because of the greater distance of the posterior fossa from the auditory meatus at this age. Hulke believes that in young people the abscess is located usually above the tentorium—in old people below. These abscesses may be multiple. Elsewhere in the body it is only the chronic abscesses which are encapsulated.

Certain accidents peculiar to these cases, or certain changes arising in regard to unusual events should for a moment here detain us. It has been asked, for instance, whether an abscess can form in the brain as the result of ear trouble and remain stationary, while the ear disease becomes cured. This would seem improbable, although Gruber has insisted upon its occurrence in at least one case.

May fresh abscesses form in the neighborhood of an encapsulated one? It would appear that in this neighborhood tissues are indolent and likely to degenerate or atrophy, and that then slight disturbances may cause œdema or inflammation, just as these may occur around a brain-tumor. Should the inflammatory products become infected, of course a new abscess may result; and such infection is possible from leakage from the old one. In fact, Macewen has described a remarkable case in which an extramural abscess formed so completely around the old one that the capsule containing pus was found floating in the sac of the secondary abscess—floating in a pool of pus.

Can an estimate be formed as to the size of a cerebral abscess from the amount of pressure which it produces? This is by no means possible. Pressure-symptoms produced by an abscess are less than those produced by a tumor of similar bulk; there is, on the other hand, greater liability to œdema and peripheral inflammation. Gradually-extending paralysis implies pathological activity around the abscess itself, and pressure-effects may be manifested at some distance. These abscesses vary in size within large limits, from a cavity containing less than 1 c. c. to one containing 200 c. c. Of course the very large abscesses are only met with in the least vital parts of the brain, as in the frontal lobes or the temporo-sphenoidal. Cerebellar abscesses are necessarily small. Hemorrhage may take place into an abscess-cavity and produce symptoms resembling those of ordinary apoplexy. Multiple abscesses are usually of pyæmic origin.

In many abscesses of the brain the temperature is subnormal, the cause for this contradictory condition being obscure. It seems to be meningeal involvement, which is most likely to create pyrexia. It is noted that in infective inflammations of other serous membranes, especially in the toxæmic cases, we get little or no elevation of temperature; this is particularly true of the peritoneum. If pressure-symptoms are marked, we get also a slow pulse, and when the abscess is evacuated there is a rapid elevation of pulse-rate. Frequently after evacuation of pus the temperature rises.

It is possible to have considerable necrosis of cerebral tissue, which may arise either from infective embolism or thrombosis and consequent anæmic gangrene. The coincident occurrence of abscess with purulent sinus-phlebitis or pus which is free in one or another of the fossæ of the skull has also been more than once noted.

Cerebral abscesses are located chiefly in the white matter, and superficial abscesses form usually between the brain and the dura. Those of traumatic origin are usually found in the frontal and parietal lobes; those of otitic origin most often in the temporo-sphenoidal lobe and in the cerebellum. The pons and the basal ganglia are occasionally occupied by abscess, and Abercrombie mentions one which he found in the medulla. Statistics show that cerebral abscess is four times as common as cerebellar. It is very rare in the middle lobe of the cerebellum.

Mode of Healing.—After evacuation of pus the soft brain-tissue tends to fill the gap left by its removal, and a very short time suffices for practically closing the cavity in acute cases. If after evacuation of an abscess-cavity the wound is at once closed, there is much less probability of dural adhesions than in cases which are drained. When drainage is resorted to the brain becomes anchored to the external supports, and such anchoring may produce a shock on sudden movement of the patient or sudden rising. It may even produce brief unconsciousness. Macewen states that the site of a small brain-abscess previously evacuated is usually difficult to recognize.

Tubercular Lesions.—Tubercular disease of the middle ear is more frequently met in infancy and childhood, is very insidious, is accompanied by but little pain, and often occurs without lesion of the membrana tympani, so that the seat of the disease may be easily overlooked, hearing being fairly preserved. When the disease has invaded the Fallopian canal attention may be first drawn to the local condition because of facial paralysis. There may be extensive caries of the mastoid with but little external evidence. Sometimes only a thin shell of bone is left between it and the petrous part, the interior being filled with granulation tissue and caseous masses. This caries is usually of the type known as "caries sicca," and will remain dry until invaded by pyogenic organisms. We may get tubercular invasion of the whole base of the skull, and even extension to the other side. Through this granulation tissue we may get also internal complications and tubercular meningitis. Brain-abscess is less likely to follow tubercular disease because the progressive infection is usually of the tubercular variety, and it requires ordinarily mixed infection at least for the production of abscess. While this condition is going on in or about the temporal bone we get usually some external evidence of tubercular infection in involvement of the lymph-nodes. When the submastoid and suboccipital nodes are enlarged a careful examination of the ear and mastoid regions ought to be made, also of the pharynx.

Cancer of the parts about the middle and internal ear is very uncommon. Only three or four cases have come under my personal observation. It is almost invariably a condition of advanced life, and gives rise to severe pain, which is probably at first vague and not indicative. Later, it becomes more and more localized, at least in its intensity, and such pain along with gradual enlargement should always rouse a suspicion of cancer in a patient at suitable age. We frequently get invasion of surrounding parts—the mastoid antrum, the external meatus, the temporo-maxillary joint, etc. Until a secondary infection occurs temperature is not materially affected, but if abscess, ulceration, or infective thrombosis occurs, we get speedily a leptomeningitis.

Symptoms of Brain-abscess.—In the non-traumatic cases these are very often at first the symptoms of middle-ear disease, which in a general way consist of more or less discharge from the ear, some impairment of hearing, and then usually a history of exposure to cold or trifling injury, after which the pain becomes exaggerated, but indefinitely located. Although it may be ascribed to the temporal region, yet it radiates so widely as often to confuse. Even in cerebellar abscess we get pain referred to the forehead. This pain usually becomes more and more severe, and is often spoken of as "excruciating." It may be continuous or intermittent. Vomiting is not infrequent, and may be quite unaccompanied by nausea. Chills are met early and of the most variable degree, from a slight shiver to the most violent rigor. They vary not only in intensity, but in duration and frequency. The more frequent, the more likely is it that the abscess is produced by some general infection. Temperature is but slightly elevated. Such discharge from the middle ear as has previously been noted usually ceases or diminishes. A history of cessation of discharge and of increased pain and fever, occurring at irregular intervals, is characteristic of these cases. Patients are not often seen by those fully competent to recognize the significance of these lesions during the first few days of their illness. In fact, they seldom come under the surgeon's notice until the condition is generally appreciated as serious. The complaint of pain is rarely now the dominant symptom. Percussion over the affected regions usually aggravates the pain, and there will frequently be considerable tenderness. Rigidity of the sterno-mastoid of the affected side is a sign of lesion of the sigmoid sinus. In these cases pain is often elicited on deep pressure in the apex of the posterior cervical triangle. These patients are usually slow to answer questions, and later answers may become monosyllabic. Another sign of slow cerebration is want of sustained attention. There is also progressive failure of physical power as well as of will-power. Temperature seldom exceeds 99° F., and often does not rise above 97° F. The pulse is slow, as well as the respiration-rate, and both are proportioned to the general intracranial pressure. On the other hand, in infectious thrombosis the respirations are often quickened. Vomiting now occurs relatively seldom, and probably only when the upright position is assumed. Vomiting accompanied by a persistent headache is always indicative of intracranial mischief. If vomiting be a special feature throughout the progress of the case, there is no little probability of involvement of the cerebellum. Convulsions are frequent, but not distinctive. They are the result usually of secondary irritation of motor areas. Macewen states that when pus has leaked into the subdural space or into the ventricles we are likely to note convulsive movements of erratic character, accompanied by rigidity, and tetanoid movements are sometimes noted. When convulsions do occur they should be carefully observed for localizing symptoms.

Paralysis may result from destruction, and may give considerable aid in diagnosis, since its cause is generally close to the lesion which we seek. An odor of offensive character is usually given to the breath of patients who suffer from cerebral abscess due to ear disease, and might be attributed to ordinary causes did it not so much resemble that emanating from the ear itself. Sometimes it even taints the atmosphere of the

patient's room. During the latter stage of these cases rigors are less frequent. Optic neuritis is often met with, particularly in the later periods, but not so often nor so complete as in cases of tumor.

A great deal of emphasis should be placed upon the results of a careful aural examination. If the membrana tympani be destroyed, it may be possible to recognize the destruction of one part or another of the tympanic wall, or even the escape of pus from perforations into this cavity. The careful use of a probe under these circumstances may give much information. Swelling and redness over the mastoid are not often found in cerebral abscess in adults.

This disease of course tends to produce a fatal result, either by increasing stupor and coma or by the rapid consequences of bursting of an abscess into a ventricle or into the brain-surface. Then the inflammatory activity is most rapid and pernicious. It is generally heralded by acute symptoms—vomiting, restlessness, flushing, spasms, prostration, quick breathing, and high temperature. When a ventricle is involved the symptoms are even more clear: temperature rises with a bound, muscular twitchings are associated with convulsions, and these are quickly followed by coma, and by death, which frequently results within eight or ten hours from the first indication of rupture.

Localizing Symptoms.—These are only occasional in cerebral abscess, because the majority of these lesions are situated outside the motor area. Alterations in the pupils are sometimes met with. With abscess in one temporo-sphenoidal or frontal lobe the pupil on the same side may either enlarge or diminish, but whatever size it assumes will probably remain. Moreover, it may lose its motility. With a small abscess and cerebral irritation it will probably be abnormally small; with a large abscess and great pressure it will probably be dilated. As an abscess grows the size of the pupil may increase *pari passu.* Sometimes the only difference noted is relative sluggishness of the pupil on the affected side. Infective thrombosis, save in the cavernous sinus, rarely affects the size of the pupils, and when it does there is usually ptosis as well as pupillary change.

Macewen has laid great stress upon the importance of percussion, and upon the fact that he elicits in these cases a different cranial percussion-note. He percusses with the ordinary instruments or by the tip of the middle finger, tapping lightly upon the cranium, which answers all requirements. He prefers immediate percussion with the ear upon the patient's head. He claims that when the lateral ventricles are distended with fluid the percussion-note is greatly altered, the resonance being greatly increased. He reminds us, however, that the percussion-note for a given spot—for instance, the pterion—varies according to the position of the head. In children and adolescents he gets ordinarily a clear percussion-tone over the distended ventricles, and claims that the tones over the cerebellum generally aid in diagnosis. (Incidentally, we may add here that he gets a characteristic cracked-pot sound on percussion of the head in extensive fractures.) All of which would indicate that there is a very limited field for the application of this physical sign, but that in certain cases it may be of value. Macewen also reminds us that the quantity of pus issuing from the middle ear is always to be noted, with a view to ascertaining whether or not it be greater than would

probably escape from the ear alone. If distinctly greater, then there must be an internal cavity from which it flows.

The particular signs of abscesses in particular localities may be briefly epitomized as follows: In temporo-sphenoidal abscess pain usually originates in the ear on the same side as the abscess. As the brain becomes involved we have affections successively of the lower part of the ascending frontal and parietal convolutions; then of the posterior and lower part of the third frontal; then of the posterior half of the first temporal; and, finally, the motor and sensory strands in the internal capsule may be pressed on and complete local paralysis result. Hemiplegia on the opposite side, then, is occasionally found in large temporo-sphenoidal abscesses. Sometimes this is due purely to pressure, since restoration of function often follows evacuation of pus. When the order of paralysis is face, arm, and then leg—and particularly when sensation is preserved—abscess in the temporo-sphenoidal lobe is in all probability pressing from below upward. If, however, the order be leg, arm, and lastly face, or if they be simultaneously affected, and particularly with sensory paralysis, then the probability of secondary involvement of the internal capsule is much greater. Facial paralysis is common in advanced destructive lesions of the mastoid and tympanum. To distinguish any facial paralysis produced by cortical lesion from one produced by paralysis of the facial nerve we may add that the former is seldom so intense; the patient can usually shut the eyelid, and there is commonly some power of emotional expression on the affected side, while the sense of taste in the anterior two-thirds of the tongue remains intact. In complete peripheral paralysis of the facial nerve these are absent. Aphasia is noted in some abscesses on the left side. Paralysis of the third nerve on the same side is often to be expected in large abscesses. If this be complete, we have ptosis, external strabismus, and fixed and dilated pupils, with more or less fixation of the globe. If with paralysis of the third nerve there be hemiplegia of the opposite side, commencing in the face, it is probable that the lesion is large and situated in the temporal lobe.

In abscesses in the frontal lobes we frequently get no localizing phenomena unless they are situated about the base of the third frontal or the ascending frontal, or at least implicate these areas. In large abscesses the pupil of the affected side is usually permanently dilated; in small abscesses it is commonly sluggish and contracted.[1] Macewen states that lesions in the conducting paths to the internal capsule from the cortical speech-centre may produce only transient aphasia, the speech-process being able to pass by strands to the corpus callosum and opposite speech-region.

Abscesses in the parietal region are more commonly due to traumatism, and will, in all probability, affect more or less directly the motor area, producing distinct localizing phenomena, convulsive or paralytic.

Occipital abscesses are rare except after pyæmia.

Cerebellar abscesses furnish few localizing symptoms, though when

[1] Chiene thinks that in abscess of the frontal region more stress should be laid upon the slowness of the pulse, and not so much upon tenderness and percussion (*Edinburgh Med. Journ.*, June 1, 1894).

large they sometimes set up meningitis in the posterior fossa. The prominent features usually are retraction of the head and neck; slow, feeble pulse and respiration; subnormal temperature; violent yawning; more or less rigidity of the masseters; slow, syllabic speech; more or less optic neuritis; dilated pupils; sometimes almost complete aphasia. There is often a history of vertigo and vomiting. If accompanied by thrombosis, there is pain on pressure in the upper thirds of both cervical triangles.

Pontic abscesses may present no symptoms until ruptured, when there will be general involvement of basal structures. The recorded cases present no definite nor constant features.

Diagnosis.—Inasmuch as all brain-abscesses of acute character are surrounded by an inflamed zone of brain-tissue, at least at first, it is sometimes quite difficult, even impossible, to distinguish between the signs of abscess and those of acute encephalitis. Encephalitis of traumatic origin may last longer without pus-formation than that of non-traumatic origin, and when under these circumstances pus does form, it is usually from an added infection. As between abscess and suppurative leptomeningitis or breaking-down thrombus there are also great difficulties in diagnosis, since all may arise from the same source and all may be coincidently present. With abscess near the surface there is almost always some degree of leptomeningitis, and when the abscess bursts this leptomeningitis becomes generalized and most acute. Then, of course, the symptoms of the latter prevail, while possibly only the history of the case makes the presence of abscess probable. When meningitis is present we have a high temperature without marked remissions, rapid pulse, and general irritability, the rapidity of the pulse marking in considerable degree the predominance of leptomeningitis over encephalitis, since the more marked the latter the slower the pulse. Leptomeningitis implicates the cranial nerves more generally, yet more erratically, than cerebral abscess, though if the membranous inflammation be limited to the area about the abscess, the symptoms of abscess will predominate.

The symptoms of sinus-thrombosis, especially during its disintegrating stages, are much more distinctive. Here we have high temperature with marked remissions, rapid and weak pulse, frequent chills, followed by profuse perspirations, symptoms of pulmonary infarct, diarrhœa, pain in the posterior cervical triangles, tenderness in the submastoid region and down the jugular on the affected side. In other respects these symptoms are those of the typhoid type.

When all three conditions are associated the symptoms of thrombosis usually prevail over the others, although we may get retraction of the head, due to basal meningitis. When thrombosis and abscess are both present, the former is the more serious of the two and demands first attention. In all of these cases, when they have become generally septic, the pulse is weak and rapid, and Macewen calls attention to the fact that in such cases chloroform or opium in no way reduces the pulse-rate; even after complete anæsthesia it is as rapid as before.

As between tumor and abscess, we have in the former usual absence of source and cause of infection, slow progress of symptoms, more definite localizing phenomena, progressive involvement of cranial nerves,

pronounced optic neuritis, absence of chills, and alternating periods of mitigation of symptoms. Temperature and pulse afford little help, save that subnormal temperature points rather to abscess.[1]

Prognosis.—The statement is made by all authors and those who write from varied points of view that the tendency of cerebral abscess is invariably toward fatality. Of the acute cases, those not dealt with surgically usually terminate within a few weeks. The chronic and prolonged cases, unfortunately, seldom come under surgical treatment. For those, then, which are not treated surgically there is no hope. On the other hand, for acute abscesses early attacked there is considerable hope. If we have to deal with an uncomplicated cerebral abscess whose position can be reasonably well ascertained, and can attack it early enough, the outlook is very good. The earlier the better, because we hope in this way to get at it before leptomeningitis or sinus-thrombosis has complicated the case. With proper evacuation of such an abscess we may even have complete mental and bodily recovery. Sometimes anchoring of the brain to the skull will leave a train of disquieting local symptoms, but this is certainly better than fatality. Spontaneous evacuation of superficial abscesses has already been alluded to, but it is dangerous to wait for this natural process, which, though known, is relatively very rare. That an abscess which has remained for a long time encysted may be a final source of danger was profoundly impressed on me some years ago by one of my own cases: A middle-aged man, whose boy had been a patient of mine, suddenly developed furious brain-symptoms, then

[1] *Differential Diagnosis of Brain-abscess.*—Those beginning with most acute symptoms are for the most part due to meningitis purulenta, or next to brain-embolism or thrombotic softening, as well as to an apoplexy of the brain; while the slower forms are for the most part due to extra- or subdural infections. It is often impossible to separate purulent leptomeningitis from abscess, since the one leads so insensibly to the other, and diagnosis can often be made only by localizing symptoms, if present, or by localizing lesions, such as middle-ear disease, etc. Brain-embolisms and apoplexies lack some of the etiological factors commonly met with in abscess. According to Laube (*Diagnostik der inneren Krankheiten*, 1893), brain-abscess clinically occupies a position between brain-softening and brain-tumor, and may have to be distinguished as well from the one as from the other.

According to Beck, between 1890 and 1892 there were 76 cases of brain-abscess treated by operation, of which 40 recovered and 36 died: 36 of these cases were of traumatic origin, of which 23 recovered. In 30 of these 36 puncture or incision was made for diagnostic purposes, and was followed by evacuation. In 2 cases there was later recidive of abscess-formation and secondary operations were required. In 4 of the cases in which abscess was diagnosed the puncture or incision gave negative results, although in each of them it was found—three times closely behind the point explored and once in the corpus striatum. Of these 36 cases, in 14 instances the time elapsed between injury and operation was counted in weeks; in 16, in months; and in 6, by years. Of the total of 76 cases operated, 36 times also the cases were due to ear disease, which in 10 of them had existed for years. Of these, 17 recovered and 19 died. The recoveries were all from temporal abscess, which constituted 29 of the 36, the other 7 being composed of 2 cerebellar, 3 occipital, 1 combined, and 1 frontal. In 5 cases the abscess was not discovered at the time of the operation, but upon the day following evacuated itself spontaneously, and in each instance was followed by recovery. In 4 of these cases the presence of the suspected abscess was proved by autopsy.

The other 4 of the total of 76 cases were constituted by hæmatogenic or metastatic abscesses, of which 2 were single and 2 multiple. In 1 frontal abscess operation had a negative result, and death resulted from meningitis. In 1 occipital abscess improvement followed operation, but death finally resulted from perforation into the ventricle. This case was tubercular. In 1 parietal abscess following carbuncle, after operative relief death occurred four months later from another abscess and meningitis (*Beiträge zur klin. Chirurgie*, xii. 1 et seq.).

became unconscious, and died after some days in coma. There was no symptom which would lead to exploration of any particular part of the brain; in fact, so sudden was the onset that it seemed more like hemorrhage than anything else. On autopsy we found an originally encapsulated abscess in the upper part of one of the hemispheres, which had ruptured and was surrounded by the usual acute infective disturbances. There was also found on autopsy a small scar on top of the head. Then his family remembered that a number of years before he had been severely injured upon the head, but that since then no one had thought of it. In his instance there was no known cause for the acute rupture nor the disturbance which followed.

Nauwerck reports a case of brain-abscess where, on autopsy, were found hyperæmia and œdema of the lung, swelling of the spleen, depression and perforation of the right temporal bone, defect of the underlying convolution, multiple abscess of the hemisphere, and hydrocephalous softening of the same. The abscesses in this case numbered eight, which were filled with thick green pus, the largest as large as a plum, which corresponded to the traumatic depression of the overlying bone. In this case an interval of twenty-eight years had elapsed between the reception of the injury and the final fatal result. This would appear to be the longest time of quiescence in these cases on record.

Let us, then, sum up the whole question of prognosis, and say that recovery from cerebral abscess hinges entirely upon its early detection, accurate localization, and proper evacuation.

Sinus-thrombosis.

By virtue of their construction the sinuses are predisposed to thrombosis. Their size, the inflexibility of their walls, their typical shape, the trabeculæ occasionally found in them, the fact that they are not emptied during respiration, and in some instances the direction of the blood-current which enters them, all tend to retard the flow and predispose to coagulation. If to these be added deficient blood-supply, then everything predisposes toward *marasmic thrombosis.*

This occurs less frequently than the infective, and is almost always met with in the longitudinal, rarely in the basal, sinuses. It occurs most often in marasmic individuals, and is noted most often at the two extremes of life. Exhausting diarrhœa is one of the most common causes in children, although conditions which bring about dilatation of the right side of the heart are also frequently operative. In the marasmic form the clots are dense, firm, stratified, and usually non-adherent. They seldom occupy the whole calibre; they tend early toward organization and rarely disintegrate. In old cases the clot may be tunnelled sufficiently to permit re-establishment of circulation. Congestion and œdema naturally depend upon them, the amount of the same depending upon the extent of the clot and its ramifications. In the more severe cases even the ventricles become distended with serous blood, and exophthalmos caused by sero-sanguineous effusion into the orbits has been known. The frontal lobes are the least affected by the œdema and subsequent softening; the parietal and occipital the most so. Meningeal hemorrhages occur now and then, and atrophy may result therefrom.

The **symptoms** are uncertain; they may be characterized by the condition which gives rise to thrombosis. The longitudinal sinus being most often involved, we get venous distention in the frontal and parietal regions, with more or less external œdema. Sometimes epistaxis results. Strabismus, tremors, contracture and rigidity of muscles, etc. are occasionally met with. Children often have convulsions; sometimes these are unilateral, and in these instances probably indicate thrombosis in the motor areas. Retinal thrombosis is sometimes noted.

Diagnosis in adults is difficult, and often not made, except in those cases where cerebral symptoms otherwise would not occur. In children, convulsions after exhausting illness, with the signs above noted, render marasmic thrombosis much more recognizable.

INFECTIVE THROMBOSIS.

This constitutes the other variety of sinus-thrombosis, and is due exclusively to the invasion of pathogenic bacteria. It occurs most often during middle age, occasionally in the very old or very young. It usually is met with in one of the basal sinuses. Its origin is local, it being always secondary to some external infective lesion, and it occurs at the point nearest to the primary source of infection. It may be due to lesions of traumatic origin, such as occur after compound fractures, etc. The most frequent cause is middle-ear disease, and, consequently, the sigmoid sinus is the one most commonly affected. Carbuncles of the face are also frequently followed by sinus-thrombosis, as may also be erysipelas or infective cellulitis or nasal ulceration. Infective periostitis due to dental caries, tonsillitis, and retropharyngeal abscess have also all been known to be sufficient causes for sinus-thrombosis, usually of the cavernous sinus.

Infection may be propagated by mere continuity of tissue, or the elements of infection may be carried by the circulation.

After an infectious thrombosis there is rapid disintegration of the sinus-lining, with complete occlusion by the clot, so that hemorrhage rarely occurs. A true sinus-phlebitis thus set up causes firm adhesions between the clot and the sinus-walls. A little later the clot begins to disintegrate, pus is formed, and the resultant fluid is a mixture of blood-elements and pus. This swarms with bacteria, which frequently escape farther into the circulation. The clot frequently extends into the internal jugular, which then participates in the same processes, while the same lesions are repeated; and the same is true of the other venous connections with the basal sinuses. The phenomena are slightly different outside of the skull from those inside, because outside the venous walls have less power of resistance and there is more opportunity for the dislodgement of clot. Between the sinus and the bone surrounding there is separation, and frequently a collection of puruloid fluid, which in time macerates the firm texture of the sinus itself, as well as deprives it of its blood-supply. It is under these circumstances that pus frequently finds escape along the mastoid vein out through the mastoid foramen, and sometimes to such extent as to produce an extracranial abscess. By the same process there may be extension along the posterior condyloid foramen with formation of deep cervical abscess, or along the anterior

condyloid foramen, along the twelfth pair, and along the vein which communicates with the vertebral plexus. On the other hand, along with such involvement of the sinus-wall we are likely to get acute lepto-meningitis, although this may not occur faster than protective adhesions may form which shall shut off infectious products.

The result of all this disintegration within bony channels is to produce a marked effect upon the bone itself, which becomes pigmented, discolored, and eroded. The discoloration probably is due to the bacillus pyocyaneus. Sometimes there results deep staining along the venous grooves, and the soft tissues may also participate in this stain.

Supposing the infection and resulting disturbance to be mild in degree, there may be reaction in the direction of formation of granulation tissue around the sinus-walls, which will penetrate into the eroded bone on one side and into the lumen of the vessel on the other. By a later organization of this we may get complete obliteration by fibrous tissue. This granulation tissue may act as a barrier, and form a most pronounced sanitary cordon as against the advance of infectious processes. Should it be detached, its very object may be defeated. Hence the misfortune of incomplete operations.

The terminal limits of most of these thrombi are protective, since disintegration does not usually extend so far. Thus in the internal jugular a cord-like mass may be felt under the sterno-mastoid, often extending well down the side of the neck. This, of course, is protective, and the sooner such a thrombus organizes and adheres completely, the sooner is possibility of pulmonary infarction through the jugular shut off. Hence, too, the practicability of attacking the jugular in many of these cases and washing through from above. It is even on record that the superior vena cava has been completely occluded in this way and in the same fashion.

By extension from the visceral side of the sinuses we may get cerebral or cerebellar abscesses as well as purulent meningitis.

Symptoms.—Infective thrombosis does not give rise to distinct pathognomonic symptoms. There is local ischæmia, with interference of function and extracranial œdema. The general symptoms are those due to dissemination of septic material. Headache is nearly constant, the pain being sometimes extremely severe. Vomiting is frequent. Temperature usually runs high, with marked remissions. The pulse is small and rapid, and remains so even when patients are narcotized. Chills are frequent; they occur early and perhaps often, and the tendency is toward greater frequency as the condition becomes worse. They are of the pyæmic type, followed by copious perspiration. The general appearance of the patient is typhoid. Sometimes the lungs become involved insidiously; at other times the occurrence of pulmonary infarction is easily recognized. In either case we usually have dyspnœa with cough—complaint of pain in the chest whose location varies with the succession of infarctions. At first physical examination may give negative results. After a day or two we get prune-juice expectoration, coarse râles, followed later by moist râles; the sputum becomes putrid; there is great fetor of the breath; and the presence of infective pneumonia cannot be doubted.

Cerebral function is at first active and unimpaired; intelligence often

lasts nearly to the end. The duration of the disease ordinarily is from two to four weeks, death resulting from exhaustion and sepsis.

Macewen has described a typhoid or abdominal type in which the toxæmic symptoms are particularly manifested in the abdomen. In these cases the skin is occasionally affected with a rash, which does not disappear on pressure. The symptoms in many respects strikingly resemble those of enteric fever, and experienced physicians have been misled. This is more apt to occur when otorrhœa has not been observed or is regarded as insignificant.

When meningitis occurs early by extension we have more violent headache, often referred to the frontal region, frequent vomiting, persistent high temperature, fewer chills, great excitement, spasms of the upper muscles of the body, strabismus, with delirium and coma at the last. If the sigmoid sinus is involved, there is usually retraction of the head, perhaps to the affected side. If the leptomeningitis be diffused down the spine as well, there are girdle-pains complained of, and there is absolute prostration.

In certain cases, aside from the above-mentioned brain-symptoms, we have peculiar disturbances due to stasis of blood in certain limited areas. For instance, we may have exophthalmos on one side or both, along with conjunctival injection, œdema of the lids, and disturbances of vision. These symptoms occur in thrombosis of the cavernous sinus and are produced by stasis in the ophthalmic vein. In these cases it is possible for the frontal veins which empty into the ophthalmic to be also compromised.

Other features of deep thrombosis may also be mentioned. Thus, Dusch noted thrombosis of the superior longitudinal sinus in a boy suffering repeatedly from epistaxis. Gerhard has described a *dissimilar* filling of the external jugular veins. In thrombosis of one transverse sinus only the internal jugular on that side will carry less blood than it otherwise would; so long, however, as the transverse sinus of the other side is free, it will receive the current which cannot pass through the obstructed one, and consequently the jugular on its side will carry more. If the contained clot extends so far as the direct communication with the internal jugular, or even so far as the opening of the inferior petrosal sinus, then the *internal* jugular of the affected side will be almost empty, while the *external* jugular on the same side will be the more distended. Thus, Schwartze noted one case in which a clot extended from the superior longitudinal into the right transverse and petrosal sinuses clear to the jugular foramen, while the left transverse sinus was almost free, the right external jugular being inordinately distended. In very young children, as a result of the consequent anæmia, the large fontanelles will usually be found depressed, although when a large amount of blood has been poured outside of the membrane they will more or less protrude.

When the general signs and symptoms of sinus-thrombosis are present, it may be possible in certain cases to determine more or less accurately the site of the thrombus. When the eye is protruded, the lid œdematous, and the frontal vein distended, it must be plain that the cavernous sinus on that side is involved. When, as often occurs in children, superficial veins of the scalp are distended, especially in the neighborhood of the parietal foramen, then it will be found that the

superior longitudinal sinus is at fault. When this is seen posteriorly or in the neighborhood of the mastoid foramen, we locate the thrombus in the transverse sinus. When there are no localizing symptoms of this character, we can only say in a general way that internal thrombosis has occurred.

Prognosis is always unfavorable, although recovery is not impossible. The therapeutics are, for the most part, prophylactic. By actual physiological rest it is possible at least to reduce the liability of embolism of the lungs. (See Abscess following Middle-ear Disease.)

Sinus-phlebitis.

PHLEBITIS SINUUM DURÆ MATRIS; COLPITIS CEREBRALIS.

Inflammation of the cerebral veins may occur in two ways: First, as the result of thrombosis; second, as the continuation of inflammatory or suppurative processes from neighboring infectious processes.

Thromboses produce sinus-phlebitis by penetration of the infected particles into the occluded sinus, by which a putrefactive condition of the clot is brought about. On the other hand, inflammation and suppuration may extend from neighboring tissue, and are more likely the nearer such processes are going on. Even chronic inflammation and chronic suppuration may give rise to acute sinus-phlebitis, and in these cases the primary trouble may be at some distance from the sinus. Acute suppurations spread apparently by mere continuity of tissue without reference to the relative position of parts. They often also follow the vessels and nerves, or rather work their way along the connective tissues surrounding them, and thus penetrate from the dura into the sinus. But in the great majority of instances the veins which empty into the sinus are directly responsible for the propagation of the lesion. The circumstances which must obtain to produce this condition are injuries or infections which produce phlegmon or phlegmonous erysipelas of the scalp, or which produce infectious inflammation of the bone. Of the former, those involving the orbital and parotid regions are the most common. So also carbuncle upon the face or upon the scalp, and suppurative processes going on within the nasal cavities or within the various cavities contained within the cranial bones. Of the chronic conditions, by all means the most common are those connected with the middle ear; and here, of course, the close proximity of the transverse sinus to the mastoid emissaries plays a prominent rôle.

In sinus-phlebitis the walls of the sinus are thickened, infiltrated, and its lumen more or less completely filled with the breaking-down thrombus. The veins of the brain and its membranes are overfilled, and extravasations in the cortex often complicate these cases. In fact, too often along with sinus-phlebitis we find apparently pachy- and leptomeningitis, and not rarely even an abscess in the brain-substance. Pachymeningeal inflammations are frequently confined to the immediate neighborhood of the sinus, while leptomeningitis may extend over a large area. When the disease does not run too acute a course we are likely to have breaking down of thrombi and consequent infarcts of the lungs, which may go on to the formation of abscesses, which later may extend to spleen, liver, and kidneys.

Symptoms of sinus-phlebitis scarcely include those of formation of thrombi, and this is particularly the case when the primary inflammation is limited to a very small area of the overlying bone. There may result changes leading even to perforation of the sinus, without coagulation in the same. This constitutes, in effect, a destruction of the sinus-wall without previous thrombosis, by which profuse hemorrhage may result. This has been observed, for instance, in the transverse sinus after caries of the temporal bone, especially in the mastoid portion. But, as a rule, thrombi form, and this kind of hemorrhage is prevented. In rarer instances there is found circumscribed thrombosis, by which the inflamed vein is later completely obliterated. In one case reported by Zaufal the transverse sinus connected with the mastoid cells by an opening of considerable size, and the walls of the transverse sinus were completely occluded by a yellowish connective tissue. Sinus-phlebitis is more common in the transverse and cavernous sinuses, less so in the superior longitudinal. The inflammatory process extends from its original seat in the direction of the blood-stream. Not infrequently it extends into the internal jugular vein. When it depends upon a primary thrombosis its extent is coexistent with that of the original thrombus.

The **symptoms and signs** are seldom of themselves absolutely diagnostic. The sinus-inflammation is often accompanied by meningitis or even encephalitis. The principal symptoms consist in brain-irritation and brain-pressure, to which should be added fever, frequently high, often with pyæmic accompaniment.

The first symptom usually complained of is severe headache, frequently localized and made worse by pressure over the region involved. Loss of appetite, with more or less mental disturbance, and sometimes delirium, follows. These patients sometimes vomit, and are frequently very restless. Their delirium usually becomes aggravated into a mania, which in quickly-fatal cases is followed by stupor and coma. Sometimes there are spasms of the cervical muscles, and often convulsions of groups of muscles of the extremities, followed by paralyses. In the less-rapid cases chills frequently occur, and sometimes symptoms of irritation or paralysis along particular nerves, as, for instance, the oculo-motor, the abducens, or the vagus. Muscular paralysis usually merges into apathy and weakness, which finally merge into coma. When pyæmic symptoms occur they are very vague, and appear rather as pneumonia, pleuritis, and jaundice. When these appear in conjunction with aggravating brain-symptoms they indicate a speedily fatal result. The disease may last but a few days or it may spread over several weeks. In the most acute cases death results within a week.

The symptoms will in large measure depend upon the probable sinus most or primarily involved. They are most characteristic when the cavernous sinus is at fault. In inflammation in this locality we have a number of disturbances in the eye on the affected side, including congestion of the orbital veins, with possible inflammation of the same and compression of the oculo-motor nerves, perhaps also of the first branch of the fifth on the same side. There is also very likely to occur paralysis of the carotid plexus of the sympathetic. At first there is pain in the eye, and it is sensitive to light; the pupil is small; then the cornea becomes cloudy, the eyelid and conjunctiva œdematous; there is more or

less exophthalmos; the pupil becomes dilated; the cornea loses its polish; the sight is lost; the upper lid cannot be raised; and, if these symptoms persist long enough, we have ulceration of the cornea. In most of these cases also we have complaint of pain in the frontal and supraorbital region, increased upon pressure, sometimes also difficulty in moving the tongue, and the consequent thickness of speech due to pressure-paralysis of the hypoglossal nerve. This is probably to be met with in hemorrhages beneath the pia in the region of the hypoglossal nucleus.

When the transverse sinus is involved we have irritation, and, later, paralysis, of the vagus, indicated by the slowing and weakening of the pulse; and of greatest value are certain paralytic sequences, such as paralysis of the muscles of the lower jaw, the tongue, the palate, and pharynx, owing to which the mucus in the larynx and pharynx cannot be expectorated. Also the diaphragmatic motions are interfered with and the character of the inspiration is changed. As the trouble extends from the transverse sinus into the internal jugular, we have further paralysis of the nerves which have their course alongside of it. This means paralysis of the hypoglossal nerve proper. As the lesion extends down the jugular vein, we have tenderness in the neck, limitation of motion, and frequently swelling. Very often also we have tenderness over the mastoid process, with acute pain in this area.

The symptoms of inflammation of the superior longitudinal sinus are the most vague of all, and are those rather of diffuse meningitis than of involvement of special nerves. Pain complained of in this case is usually referred to the temples.

As the trouble extends from one sinus to another, the symptoms are modified accordingly or spread from one side to the other. Thus, when one cavernous sinus is involved the trouble almost always extends to the other side, and the local symptoms are repeated. From the transverse sinus lesions frequently extend into the petrosal, upper and lower.

Diagnosis.—It must be said that the primary symptoms are frequently those which are common to this condition, to thrombosis, and to meningitis alike. When in these instances a case presents pyæmic disturbances, chills, symptoms of lung-involvement, swelling of the joints, and so on, one can with reasonable definiteness eliminate the meningeal form. Obviously, however, diagnosis is easier when a plain reason for sinus-phlebitis is at hand, as, for instance, the history of injury or middle-ear trouble, of abscess, of carbuncle, etc. The farther away the original cause is from the membrane, and the less plausible the extension by continuity may appear, the more likely it is that we have to deal with sinus-phlebitis. Should there be a considerable amount of disturbance of the nerves, the diagnosis is easy. Thus, oculo-motor paralysis, ptosis, pupillary alteration, etc., occurring early, are of great importance, and the history should be carefully considered. Even eye-symptoms point primarily to the cavernous sinus, whereas lesions involving the vagus or hypoglossal or the glossopharyngeal nerve point to transverse sinus or to basal involvement. When symptoms belonging to one of these groups are lacking, one may think of the convex surface of the brain, and, if the patient complain of temporal or frontal pain with tenderness in these regions, it may be that the superior longitudinal

sinus is involved. Pain and tenderness over the mastoid or down the neck point rather to the transverse sinus as primarily at fault. As between lesions of this kind of infectious character, as they are usually, or of the marasmic form of thrombosis, we may judge by the history of the case, the general appearance of the patient, the absence of neighboring infectious disease or injury, the absence of fever and pyæmic disturbance, and the less severe character of the disease.

The Cerebral Membranes.

Aside from what has been already said of these membranes, they deserve a little further consideration here.

PACHYMENINGITIS.

The dura mater has two distinct purposes: first, as an internal periosteum, and, second, as a distinct covering for the brain. This will account for its duplicate anatomical character, its outer surface having the structure of periosteum, and its inner surface being lined with endothelium; accordingly its involvement may partake either of the nature of periostitis or of inflammation of a serous membrane. The former has been usually known as endocranitis or pachymeningitis externa; the latter, as pachymeningitis interna.

Pachymeningitis Externa (Endocranitis).—This is seldom primary, but is usually the result of extension of trouble from the overlying bone. After injuries one meets with thickening and indurated, firm adhesions, just as we meet with them in any other parts of the body. When these injuries are complicated with open wounds and suppuration follows, we may have a suppurative form of endocranitis, with hemorrhages between the bone and dura, and resulting inflammation extending beyond the immediate limit of the injury. Thus the entire membrane may be infiltrated with purulent products, and, if speedy exit for the pus be not provided, extension may take place from the dura to the pia within. Suppuration between bone and dura without injury to the skin is very rare, but when there has been a subdural hemorrhage, with more or less injury to the skin, the extravasation sometimes suppurates, and then we may have subdural abscess. Such an abscess, therefore, may follow contusion of the scalp. Collections of pus thus circumscribed, which cannot perforate through the suture, may escape by perforating through the bone or may determine leptomeningitis or sinus-phlebitis.

As a rule, pachymeningitis externa is most common after chronic suppurative processes of the cranial bones—*i. e.* caries and necrosis. So soon as this infectious process has reached the membrane it begins to thicken and its outer surface to granulate, by which the parts beneath are protected. In this way pus may be shut off from the underlying portions for indefinite periods of time, although such a patient is always in danger. Again, while chronic suppurations of the bone frequently produce very acute forms of endocranitis and sinus-phlebitis, the infectious process in such cases may extend along veins or nerves and gain access to parts beneath.

So far as **symptoms** are concerned, they are usually not characteristic, and frequently not distinguishable. Chronic suppurative external pachymeningitis will produce fever, local tenderness, pus, perhaps focal symptoms, by which it may be localized. Still it must be said that these symptoms may be produced by various different causes.

Prognosis is less favorable in more acute cases, although most cases of endocranitis alone will recover.

Treatment.—The treatment, except perhaps in syphilitic cases, will be for the most part surgical, and under all conditions which produce suppurations of this kind it will be not only justifiable, but strongly advisable, to operate. Should any focus of softening or destruction be found, it should be freely uncovered, disinfected, and drained, it being best to allow healing to occur by granulation and arrange for free exposure and easy dressing of the part.

PACHYMENINGITIS INTERNA.—This condition hardly belongs within the domain of surgery, yet, I think, is connected with conditions most strictly surgical. It has often been confounded with chronic hydrocephalus. As one characteristic it results in the production of a membranous exudate on the inner surface of the dura, which is easily separable from the same, and which may have added to it new layers of the same material, providing the disease lasts long enough. This new membrane is rich in very fine vessels which are extremely friable, and hemorrhages therefrom give rise to those conditions usually spoken of as pachymeningitis hæmorrhagica. Trifling hemorrhages will not be discovered. Those of greater extent, occurring between the dura and the false membrane or between the layers of the latter, have been often spoken of as hæmatomata of the dura, and may give rise to localizing brain-symptoms. Such extravasations may be absorbed or may undergo fluidification, and produce the so-called hygromata of the dura, which appear as serous collections of fluid.[1] These collections may increase in amount and produce symptoms in some respects resembling those of hydrocephalus, or they may break down into purulent collections after pyogenic infection.

Pachymeningitis interna involves most commonly the dura covering the convexity of the brain, and most often those portions along the falx. The hæmatomata which they produce are usually arranged along the superior longitudinal sinus.

Pachymeningitis interna often occurs after acute disease. This is especially true of pneumonia, pleurisy, whooping cough, typhoid, recurrent fever, and the acute fevers in children. In these cases it is manifested usually by headache, vertigo, mild delirium, alterations of the pupils, and cramps in the extremities. Recovery is quite possible, but usually with adhesions between the dura and the pia which may lead to subsequent cerebral complications. It occurs both in very young children and in the aged. In very young children it produces often vomiting, convulsions, and various uncertain symptoms. Thus, Berard observed a child fifteen months old which had lost sight and hearing and presented enlargement of the head. He considered the case one of hydrocephalus, and desired to puncture it. The child died after a series of convulsions. On autopsy he found between the convexity of the

[1] *Vide* Intracranial Tumors; Arachnoid Cysts (p. 750).

brain and the dura a circumscribed collection of fluid amounting to twenty-four ounces.[1] Hasse found in a young man of twenty, who had died of typhoid, and who in early life had suffered from a supposed acute hydrocephalus, a circumscribed collection of fluid which had produced both protrusion of the overlying bone and atrophy of the underlying brain. These were both cases in which a clear recognition of the conditions might have permitted surgical relief, and show how this condition may be mistaken for acute hydrocephalus. The most characteristic symptom is the very gradual aggravation of a very slowly-developing brain disease, along with such indications of irritation as altered pupils, disturbances of the eye-muscles, and perhaps of other groups of muscles, these disturbances being usually unilateral, or at least more conspicuous upon one side than upon the other.

The **prognosis** is usually unfavorable, but many cases seem to halt after having reached a certain point, and to remain stationary until death is induced by some intercurrent affection.

The **treatment** must be surgical, since anything short of free incision and evacuation will, in cases which produce symptoms of the above kind, be followed by little or no result. Thus, Bruns reports a case of Graefe's which was considered a case of meningeal hydrocephalus, in which, after repeated punctures, recovery ensued, with subsidence of the unilateral dilatation of the skull. This must have been a case of hygroma, so called; in other words, a case of unilateral pachymeningitis interna with circumscribed meningeal effusion.

PACHYMENINGITIS INTERNA HÆMORRHAGICA.—This is a quite unusual condition of the dura, which seems to have been met with more frequently on this side of the ocean than on the other. It is characterized by new formation of connective tissue upon the inner layer of the dura, which at first is very thin and looks more like a chocolate-colored stain, while, as time elapses, this very thin membrane becomes thicker and stratified, and in its substance connective tissue develops which contains delicate capillary vessels whose walls are very thin. These vessels are really derived from those of the dura. With the lapse of time this membrane may form layers similar to those observed in the interior of aneurysmal sacs. The oldest is the firmest, while that last formed is soft, gelatinous, and affords but little support to its thin-walled vessels, from which occurs the hemorrhage which is characteristic of this condition. Some fluid may escape by filtration, but the main source of hemorrhage is from rupture of these new vessels, in consequence of which we may have abundant hemorrhage. Indeed, clots thus formed may reach the thickness of an inch or two, and by their bulk cause compression of dangerous, even of fatal, character. These clots usually occur over the cortex, and when long existent may undergo changes spoken of elsewhere, so that later we may find cysts filled with serum. That the beginning of this disturbance is inflammatory seems proven by the firm adhesions of the membranes and failure of the clot to gravitate. Hemorrhages may occur between the different layers of the new membrane, which will more easily account for the cysts above spoken of.

The **symptoms** are vague, but concern the surgeon, and may be epitomized as follows: The first symptom is well-defined headache, which

[1] *Vide* Hydrocephalus Meningeus (p. 732).

will increase in intensity with every new escape of blood. This cephalalgia is usually vertical. The next symptom is paralysis, which will depend upon the situation and size of the clot. Sometimes it may be possible to indicate its location very accurately. As the result of repeated hemorrhage one may have gradual atrophy of one or both of the hemispheres. Actual paralysis is often preceded by inco-ordination of muscle-groups. The absence of disturbance in the cranial nerves points to surface clot upon the convexity rather than to a ventricular hemorrhage. The third symptom is contraction and immobility of the pupils, followed by dilatation when compression is pronounced. Pupillary contraction for some time before an attack of unconsciousness is of great diagnostic value.

After the disease has been long existent we have usually optic neuritis. Coma is also a most valuable symptom, which comes on slowly, the degree of hemorrhage being indicated by the rapidity of its onset. It may be preceded by mental apathy and somnolence. These are, as Dennis has shown in a valuable paper,[1] the chief diagnostic symptoms of this condition. Not one of them but what may occur in other conditions, but their peculiar symptom-grouping is more or less characteristic of this disease. Taken along with a history of chronic alcoholism, they make diagnosis fairly certain. It has been a particular service rendered us by Dennis that he has recommended trephining under these circumstances for the purpose of revealing the presence of a blood-clot or cyst, and of effecting by its removal the amelioration and cure of the condition. Hitherto the treatment of pachymeningitis interna hæmorrhagica has been purely medical, and consequently has been of little or no avail. Dennis has reported nine cases operated on by himself or his colleagues which amply demonstrate the value of the procedure, and stamp it as a very distinct and decided advance in the application of surgical therapeutics to intracranial disease.[2]

LEPTOMENINGITIS.

In inflammation of the inner membrane of the brain we have to deal with changes in a soft, œdematous connective tissue, in which distinction as between arachnoid and pia has disappeared, and which extends into the various folds and fissures of the cortex. This common inflammation is known as leptomeningitis, which is often of a suppurative type. It results not merely from extension by continuity from external inflamma-

[1] "Operative Interference in Cases of Cerebral Hemorrhage not due to Traumatism," *N. Y. Med. Journ.*, Dec. 24, 1892, p. 703.

[2] *Vide* also paper by Buchanan (*Pittsburgh Med. Review*, Sept., 1894), with reports of six other cases by himself and others. Ceci, in 1887, invited attention to operative interference in cases of hemorrhage due to pachymeningitis hæmorrhagica chronica, and presented a case of this kind to the Society of Italian Surgeons during that year. His case occurred in a farmer fifty-two years old, who received severe injury to the right parietal bone, which healed without treatment; two months later he developed a rapidly-progressive paralysis of the left side. The diagnosis of formation of abscess seemed most plausible, and was supported by a cicatrix and a shallow depression. After the bone was opened the changed appearance of the dura, which was firmly adherent to the bone, was evident; when this was incised it was found much thickened and discolored. Beneath it was fluid blood mixed with old coagula. The patient recovered from the operation and his paralysis entirely disappeared. Birch-Hirschfeld was the first to describe pachymeningitis hæmorrhagica beneath the seat of a cured fracture of the skull. Such cases are occasionally met with.

tion of the same grade, but is occasionally the result of primary inflammatory processes or breaking down of neoplasms. After having once begun, it spreads rapidly, in contradistinction to similar inflammation of the dura. The fluid contained within the meningeal cavities of the brain, mixed with pyogenic agents, helps to spread the active factors of the disease wherever the membrane extends. Consequently, a basal leptomeningitis usually extends down the spinal canal. The arachnoidal cavity is then practically always found filled with fibrinous purulent exudate. Even the ventricular contents usually partake of the same mixed character, while the small veins, both of the membrane and of the cortex, are commonly filled with breaking-down clots. The most frequent cause of this condition is disease of the middle ear, the above infection occurring along the facial and acoustic nerves, since by numerous observers these nerves and their surrounding tissues have been found loaded with bacteria or infiltrated with pus. Next most common as provoking causes are sinus-phlebitis and endocranitis. Extension may occur from the nasal cavity.

The **symptoms** of leptomeningitis are those of increasing brain-pressure with increase of fever. The trouble usually commences with headache, followed by vertigo, acute anæmia, excessive reduction of weight, hyperæsthesia, restlessness, crying, delirium, loss of sleep followed by somnolence, symptoms of muscle-rigidity; later, paralysis, then coma and death. When the disease extends from the middle ear we frequently have facial paralysis before the meningeal symptoms appear. The type of fever is one of gradual increase in severity, although before death the temperature often falls below the normal. Those cases which are clinically characterized by chills are for the most part complicated with phlebitis. The pulse is usually rapid. With the ophthalmoscope signs of intracranial pressure may also be discovered—first, neuritis, and later choked disk. In most of the cases albumin will be found in the urine.

Prognosis is nearly always bad. Many cases end in forty-eight hours; others may extend over two weeks.

Differential **diagnosis**, as between sinus-phlebitis and leptomeningitis, depends for the most part upon the recognition of suppurative pyæmic symptoms. When the latter are entirely wanting, we may say that the predominating symptoms of sinus-phlebitis are absent.[1]

INFLAMMATION OF THE BRAIN (ENCEPHALITIS).

The etiology of purulent encephalitis is practically that of the previous condition—leptomeningitis. Aside from injuries, it includes, for the most part, suppurations or infectious processes in the membranes or cranial bones or their immediate surroundings. It may proceed from sinus-phlebitis or from the veins emptying into the sinus, the infectious process in this case extending backward into the smaller veins. Less often it extends along the cranial nerves. There occur also many cases in which the path of infection from the primary focus outside of the brain into the local focus where the abscess is found is not easily made

[1] In this connection *vide* a very interesting paper by Ricketts, "The Removal by Trephining of Fluid in Acute Cerebral Meningitis," *Internat. Med. Mag.*, Dec., 1894, p. 822.

out—at least cannot be detected by the naked eye. Thus, for instance, I have already reported a case of multiple abscess in each frontal lobe following operation for relief of hypertrophy in the nose. This is to be explained probably by the lymphatics, for the lymphatic connections with the interior of the brain are very minute and somewhat indirect; or the case may be mechanical and of embolic origin. Bergmann has reported a case of caries in the occipital bone with firm thrombosis of the right transverse sinus, while through the involved portion of this sinus the two inferior cerebral veins passed, which were filled also with small thrombi, and which led directly backward to two abscesses in the right occipital lobe.

Suppurative encephalitis may run either an acute or a more chronic course. The more acute, the more the membranes partake of the infectious process and the more it spreads from its primary location. The acute suppurations of the brain are much less limited than the chronic. The acute abscesses have irregular boundaries, while chronic abscesses seem to have abruptly-limited borders, the older ones being lined with abscess-membrane.

Symptoms.—These will depend largely on the portion of the brain most involved and the acuteness of the process. So long as the collection of pus does not encroach seriously, the symptoms may be almost completely lacking. When present they are largely those of brain-pressure, frequently combined with localizing symptoms. When these combine with œdema they are more distinctive. Should symptoms pointing to brain-abscess or those of purulent leptomeningitis be added, the diagnosis may be almost positive. Convulsions, with loss of consciousness, vomiting, slowing of the pulse, and laborious breathing, are conditions which follow a serious form of encephalitis. These are commonly followed by sopor, coma, and death. If combined with pyæmic symptoms, they point rather to sinus-phlebitis as the origin of the condition. Old collections of pus within the brain may lie latent for a long time and produce absolutely no symptoms. These are practically encapsulated abscesses. Under various conditions these may awaken into sudden acute activity and prove rapidly fatal. In cases of an intermediate degree of severity there may be paralysis of certain areas or certain special nerves, or the disturbance may assume the epileptiform type. When active trouble is aroused, it is usually ushered in by chills. The brain-tissue around the original focus becomes inflamed and œdematous, and pus may break into a ventricle or into the meningeal cavities. In some cases but a few hours elapse between the first symptoms of trouble and the terminal coma by which life is brought to a close.

The Relations of the Mastoid to Middle-ear Disease and Brain-abscess, and the Treatment of "Mastoid Disease."

Lange[1] has alluded to the disadvantage of packing powdered boric acid into the external meatus in cases of suppurative disease of the middle ear, since, because of its difficult solubility and the disposition it has to pack down, it hinders free secretion, and rather encourages infiltration of pus into the mastoid cells. He quotes Schwartze in an

[1] *Archiv für klinische Chirurgie,* vol. xlvii. p. 53.

address before the Otological Section in Berlin, 1886, of the German Naturalists' Society, that it has been necessary to operate upon the mastoid much oftener in cases in which boric acid had been thus used than in those where it had not been used, and is convinced that a direct extension of the suppurative process is to be ascribed to this mode of treatment.

There is also great danger in endeavoring to wash out the ear through the Eustachian tube, since by the current thus introduced pus and infectious elements are likely to be carried where they need not otherwise go. Even the method of inflation (Politzer's) is not free from the same charge.

In middle-ear disease, acute or chronic, with or without mastoid lesions, where brain-symptoms threaten, we may first give the patient the benefit of the doubt by freely opening the drumhead, both below to secure drainage, and above where pus is prone to lodge. The patient should be kept in bed and the ear irrigated with very hot water, every hour if possible. Inflation should be practised with great care, and only once or twice a day, unless extra dangerous symptoms occur. Very few days should be allowed to elapse, if the patient does not improve, before the mastoid should be freely opened. For this purpose the opening should be as large as possible. Allport has devised a special speculum or retracting device for this purpose. The mastoid should always be opened before the skull, since there is always chance of finding the focus of disease among these cells. If softening of the internal mastoid plate is met with, these bones should be gently cut away. If fistulæ are found, they should be enlarged to permit further exploration. In case the mastoid fails to show the suspected lesion, the skull must be opened.[1]

With great frequency mastoid disease is accompanied by acute or chronic inflammation of the external parts, due to extension. The lumen of the external meatus is narrowed or the cartilaginous ear is pushed away from the head, and the coverings of the mastoid process become swollen, red, heated, and sensitive to pressure. This is the general rule, although it is known to all that occasionally after free opening of the mastoid cells pus is found in their depth without any such external indication as above spoken of. Indeed, there is sometimes difficulty in diagnosis as between mastoiditis and a diffuse external otitis, either of which may give rise to the signs above mentioned. In the presence of such uncertainty one can scarcely do more than to wait, treating symptoms as they arise, preferably with the ice-bag. When, however, we are guided by a history of previous acute suppurative trouble in the middle ear, then there can be less uncertainty with regard to what should be done.

Condition of the Bone.—In 1889, Politzer wrote: "In acute purulent

[1] Buck (*N. Y. Med. Record*, June 30, 1894, p. 811), after detailing the clinical history of a case of periphlebitis of the lateral sinus, operation, and recovery, upon which several operations were made, formulates the following rule: The persistence of deep-seated pain behind the mastoid process, continuing after the mastoid antrum has been opened and drained, is sufficient warrant for making an opening into the sigmoid groove or the lateral sinus; and it is not advisable to wait until the patient has chills or until the body-temperature rises to an appreciable degree before resorting to operative interference in this direction.

inflammations of the middle ear the antrum and the cells are, almost without exception, filled with pus or muco-purulent secretion, while the parts externally are reddened and swollen." Lange believes that in this statement Politzer went too far, and claims that pus is not by any means always found in the antrum under these circumstances. For it would follow that either spontaneous recovery from this condition is often possible, or that a spontaneous perforation with drainage occurs without operation much oftener than is generally supposed.

Voltolini many years ago called attention to the fact that in most of these cases there was a great tendency to involve that portion of the mastoid to which the sterno-mastoid muscle is attached, or at least that this particular spot was almost always extremely tender. This is often due to temporary infection of the small posterior auricular lymph-node. When this is tender, as it so often is, it is almost impossible to distinguish between pain caused by pressure upon it or upon the bone. This would seem to explain the circumstance to which Voltolini called attention. As a matter of fact, tenderness along the posterior border of the mastoid is much more indicative than along the insertion of the external ear. When the middle portion of this border is very tender, it is almost certain that the underlying bone is involved.

Another symptom or sign of the greatest significance is the augmentation in volume of the mastoid process. Whether the disease be acute or slow, in young or old, the dimensions of the mastoid are practically always altered, so that on palpation there seems to be more between the palpating fingers upon the diseased than upon the sound side. This increase in size is often combined with tenderness upon deep pressure. It must, however, be distinguished from mere swelling of the soft parts.

In the ordinary cases of suppurative otitis media it seldom happens that the discharged pus is foul-smelling. When, in spite of general irrigation and the use of antiseptics, it is noticed that the pus has a foul odor, then it is almost certain that the process has gone behind the middle ear and has extended into the mastoid cells. Almost always when pus has this characteristic odor it becomes darker in color, sometimes mixed with blood, and the discharge becomes irregular in amount—sometimes less, sometimes more.

Desirable as it is that one should appreciate the true condition of the bone, this can scarcely be done without incision through the periosteum, and even then the appearance of the outer surface of the bone is more likely to be misleading than instructive. In fact, one should have practically decided to perforate or not before inspecting the bone, since by itself it gives little or no clear indication. If the symptoms point to deep mastoidal disease, the bone must be perforated, no matter how healthy it may appear.

It has been suggested to practise percussion of the mastoid area on either side, it having been claimed by Koerner and Wild that the ear of the surgeon may detect significant differences in the percussion-note in the presence of disease between the two sides.

Lange thinks that the persistence of a fair amount of hearing speaks rather against extension of disease from the middle ear than for it, and should figure in the favorable prognosis.[1]

[1] Allport's record shows that the longitudinal, superior petrosal, lateral, and transverse

(Other operative methods, with much valuable information, will be found in Samuel E. Allen's *The Mastoid Operation*, Cincinnati, 1892.)

Treatment of Intracranial Suppurations.—The general rule which applies to collections of pus in any other part of the body is equally applicable to abscesses within the brain when they can be recognized. For, first, the detection, and second, the evacuation, of purulent foci in this region operations are now regarded as not merely justifiable, but as indicated whenever the diagnosis is fairly probable. The only discussion now hinges upon the wisdom of exploration when absolutely no diagnosis can be made. When we remember the inevitably fatal tendency of these suppurations, it will be felt that there is no part of the brain in which pus may accumulate which may not be attacked with propriety, providing only we have a reasonably good indication for attacking it. Save in those instances where an opening already exists, the preliminary to evacuation of such collections consists in trephining. While most of the indications for this operation have already been mentioned in detail, there is one which, though rarely met with, is always pathognomonic. This is the spontaneous escape of pus, either through a pervious granulating wound, a fissure, or any of the natural outlets of the cranium, whether it escape directly or give rise to suggestive disturbances upon the inside of the brain. The indications laid down by Percival Pott about a century ago are still as valid as ever, but are not generally enough read or appreciated. The loosening of the pericranium, the signs of implication of the bone, the headache, chills and fever which Pott so graphically described, the evacuation of pus with the rapid disappearance of symptoms, are no rarity now-a-days, but entitled Pott to the greatest credit for being far ahead of his own time. A circumscribed collection of pus is of course an indication for deliberate trephining, since in no other way could it be reached. In the presence of evident necrosis of bone the surgeon must of course select his own instrumental means and the proper locality for use of the same. Whenever after opening the cranium the dura is found to be distended—in which instances the usual brain-pulsation will be lacking—its incision is indicated, or at least a deep exploration with the aspirating needle. Long ago Donders came to the conclusion that it was irritation of this membrane which masked the pulsations of the brain—a conclusion subsequently corroborated by experimentation in animals and by the later clinical studies of Braun and Roser.[1] According to these writers, the most common circumstance which masks brain-pulsation is the presence of pus beneath the dura. Other indications for opening it are also discoloration, or possibly its even gangrenous aspect. A few writers claim

sinuses and internal jugular are affected by phlebitis and thrombosis with about equal frequency, and these much more often than any other. Thus it does not appear that the lateral is most frequently involved. That the internal jugular is so frequently involved is accounted for by transmission of disease from the middle and internal ear by three channels: (1) By the roof of the tympanum; (2) by the small veins passing from the middle ear into the middle meningeal vein; and (3) by connection from the internal ear into the superior petrosal sinus.

Post-mortems have shown frequent cases of brain-thrombi not suspected during life. Their explanation is probably the vicarious action of the rich collateral circulation. Barr reports one case where autopsy showed complete occlusion of the lateral sinus by fibrous bands.

[1] *Centralblatt f. Chir.*, 1875, No. 11.

to have been able to detect fluctuation through the trephine opening, but this will be at least seldom possible. The most feasible method at hand for the discovery of pus lying within the brain is the aspirating needle. Its use was first suggested by Renz, and it has come into such general use here, as in various other parts of the body, that it has become a matter of routine with modern surgeons to use the hollow needle for this purpose.

To be more particular, abscess of the brain, as coming under the surgeon's notice, may be roughly divided into those cases due to middle-ear disease and those not of such origin. Of the latter, we have mostly to deal with abscesses of the hemispheres, usually of traumatic origin, although the history of the case may show that the injury was received a considerable length of time before the development of symptoms of infection. These, for the most part, are to be localized by scars or by the well-known phenomena of cerebral localization, by which or by both together the surgeon must decide at what point to open and what further course to pursue. Each of these cases is a law unto itself, and minute directions cannot be formulated.

With regard to abscesses following middle-ear disease we are in position to give more exact directions, in the main as follows: In either case rigid aseptic precautions must be observed, the head having been shaved, preferably at least forty-eight hours previously, the scalp thoroughly cleansed, and the head then enveloped in an antiseptic compress or poultice.[1] This preparation is repeated just before operating and after the patient is anæsthetized. An elastic tourniquet can be applied about the skull if the operator prefers it. There are cases of abscess in which time is not afforded for such careful preparation; the same is true also of many recent traumatic lesions. In such event the scalp must be cleansed as best it can. It is well that all possible sources of suppuration or infection from the orbit, nose, and oropharynx, as well as from the bony sinuses, should be eliminated. If there be discharges from any of these cavities, they should be made antiseptic if possible. Furuncles about the face may call for careful attention before anything is done to the cranium proper. The middle ear itself should also be carefully cleansed, since it may become a focus for subsequent infection at a most undesirable time.

Next will come up the question whether to open the mastoid antrum, the mastoid cells, or the brain-cavity proper. Indications for opening the mastoid antrum are—

1. History of repeated inflammation with swelling over the mastoid process and fistulous opening, if present.

2. Acute inflammations with signs of retention of pus.

3. Beginning symptoms of intracranial mischief with purulent otorrhœa. These call for complete exposure of the interior of the mastoid region and complete cleaning out of the middle ear.

4. Persistent otorrhœa, resisting treatment, considered incurable by aurists, even without inflammatory indications about the mastoid. This is particularly true when the discharge is offensive. Macewen insists

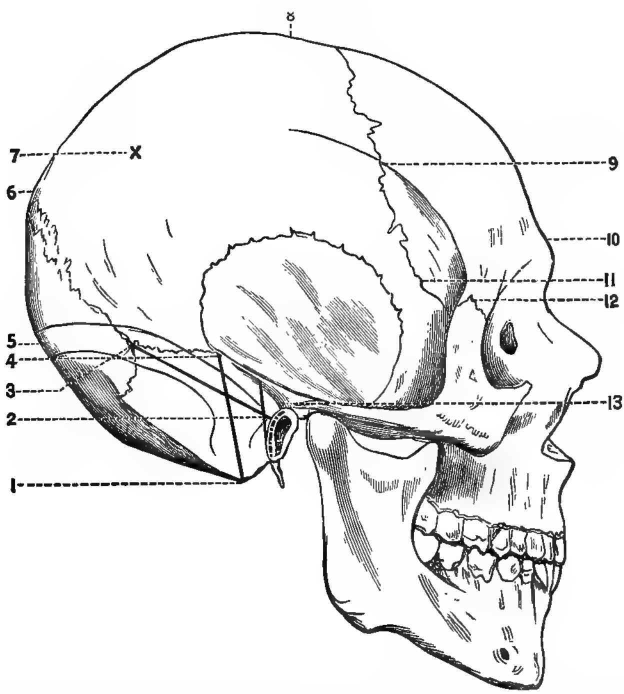
[1] The preparation which the writer prefers is to have the scalp, after careful shaving and cleansing, thickly smeared with a preparation of sapo viride to which has been added from 5 to 10 per cent. of some such antiseptic as lysol, creolin, or hydronaphthol.

that the most serious intracranial mischief is often present without marked mastoid swelling.

The mastoid antrum is the key to regional anatomy in all operations where we wish to expose the mastoid cells. In locating himself properly the surgeon will have the external ear held forward, and will place the fore finger upon the posterior zygomatic root and his thumb on the tip of the mastoid process, or *vice versâ*, and make a straight incision one-fourth of an inch behind the posterior border of the external osseous meatus, from the tip of the mastoid to the posterior root of the zygoma. This incision should extend at once to the bone, the periosteum being elevated with the soft tissues to an extent permitting full exposure of the posterior surface of the external auditory meatus.

Within the triangle, which Macewen has aptly termed "the suprameatal triangle," formed by the posterior zygomatic root, the upper and the posterior segments of the external osseous meatus, the opening into

FIG. 425.



1, tip of mastoid; 2, roof of osseous meatus; 3, asterion; 4, parieto-squamo-mastoid junction; 5, inion; 6, lambda; 7, parietal eminence; 8, bregma; 9, stephanion; 10, glabella; 11, pterion; 12, external angular process; 13, suprameatal triangle.
The short vertical heavy line indicates the base of the suprameatal triangle; the longer vertical line from 1 to 4 overlies in its upper two-thirds the sigmoid sinus; the oblique line from 2 to 3 overlies the sigmoid sinus from its commencement to its knee (Macewen).

the mastoid antrum can be made with safety. When the osseous meatus is very oblique the antrum is situated more anteriorly than otherwise. The distance of the membrana tympani from the surface should be gently measured with a probe, since if the middle ear lie deep, the antrum

may also be more deeply situated. The opening is to be made at the base of the triangle, and within it the perforation directed inward and forward so as to expose the antrum. So long as the excavation be continued in this direction within the triangle, the sigmoid groove will not be injured.

The safest instrument for the purpose of opening the antrum is the burr of some surgical or dental engine, or its equivalent rotated by hand, foot, or electric power, the size of the burr depending upon the dimensions of the triangle. In the absence of this a chisel must be used with great caution. Sometimes the outer wall of the antrum is much thickened by the disease, so that the cavity itself may appear to lie deep.

Macewen directs that after opening the antrum the surgeon determine, first, the position of the passage between it and the middle ear, and second, the position of the facial canal, which generally traverses the inner half of its floor obliquely from without inward, it being often marked by a ridge. If, however, the antrum be deeply seated and its walls sclerosed, it may be impossible to make out this canal. In these cases the antrum ought to be approached along the upper part of the external wall, so as to avoid the nerve. The occurrence of facial twitchings may announce proximity to it of the surgeon's instruments. If the antrum be filled with granulations, these should be touched with the probe, in order that if they enclose the nerve the surgeon may be aware of the fact. By taking these precautions the facial nerve is rarely injured. If granulations project from the roof of the antrum, they should be closely examined to detect whether they be protrusions from the dura. If so found, we have evidence of an external pachymeningitis. If the mastoid cells back of and below the antrum are involved, they must be exposed and their contents removed. It is safest to do this by working from the antrum downward and backward. Now, the location of the sigmoid groove must be borne in mind, since granulations springing from the dura of the cerebellar fossa and covering the sigmoid sinus may project into one of these cells.

Should the condition of the middle ear make it desirable to open the tympanum, it may be done by means of a burr applied to the junction of its roof with the outer wall of the antrum. The floor of the passage must not be encroached upon, nor its inner wall, lest the facial nerve be injured. If the malleus and incus be diseased, they should be removed. They can easily be taken out through the antrum by means of minute hooks or scoops. To leave them is to invite further extension of disease. The stapes should be left if possible, since, when it remains, hearing on that side is usually sufficient for ordinary conversational purposes. When the malleus and incus are to be removed, it is almost impossible to avoid destruction of the chorda tympani. This causes loss of taste in the anterior two-thirds of the tongue, but is seldom complained of. Macewen advises caution in injecting fluid through the antrum into the middle ear, since it may possibly run down through the Eustachian tube into the pharynx and cause laryngeal symptoms or convey infective matter into the lungs.

In the subsequent care of the case, if the ossicles have been removed, a strip of gauze may be passed through the meatus into the middle ear, and then into the mastoid antrum, it being taken for granted, of course,

that the parts have been absolutely cleansed of all infectious materials by peroxide of hydrogen or whatever the surgeon may prefer to use.

The Treatment of Temporo-sphenoidal Abscess.—If pus be found to issue through the dura above the tegmen tympani, the abscess may perhaps be evacuated by enlarging the approach, extending it outward through the squamous portion of the temporal. Such an opening may suffice for temporary purposes, though it is hardly safe to trust to it alone; and it will be better to trephine above the ear, and through the opening thus made to remove all sloughs of brain-tissue and possible infectious materials.

When such abscesses are attacked from the outside of the skull, the opening should be made as near the seat of disease as possible. If the mastoid has been already attacked, the incision may be extended upward for a couple of inches, and the centre pin of the trephine placed three-fourths of an inch above the posterior root of the zygoma. Here we come to the thin portion of the squamous bone, and the trephine must be used with caution. After exposing the dura it must be cleansed, if need be, and its color and appearance noted. If it be normal, the course of the larger pial vessels may be discerned through it. The pressure of a large abscess, however, is often enough to empty the superficial vessels, which, therefore, do not appear through the dura. Before opening it, it is well to rub into the exposed bone-edges iodoform powder, in order to protect them from contamination by infectious pus as it escapes. It is well to open the dura first at the centre of the opening, since the vessels can be more easily secured if cut. The incision in the dura ought to be in line with these vessels. Small deep abscesses may exist without affecting the cerebral pulsations. If there has been leptomeningitis, the membranes will probably be all fused together.

For the purpose of exploring for pus there may be used a small trocar and cannula, a hollow needle, a pair of sinus forceps, or an instrument devised by Horsley for this purpose, which from the opening above described should be first inserted in an inward, downward, and slightly forward direction—in the direction, in fact, of the roof of the tympanum. If pus be found, the rate of its outflow will, after a little, be influenced by respiration, increasing during expiration. Débris and minute sloughs usually come away with it, the latter being sometimes so large as to require a larger opening for their removal. It is best in this case to retain the cannula as a guide, and then, by introducing a pair of dressing forceps and opening them *in sitû*, débris can be removed, the cavity irrigated, or, if necessary, the sharp spoon be used. It is of importance to remove everything thoroughly. The cavity may be freely washed out with the boric or weak carbolic solution, provision being made for easy outflow of the fluid used. The surgeon should be absolutely sure that the fluid is going into the abscess-cavity, and the head of the patient should be finally turned so as to permit escape of the last drops of the same. If the cavity connect with the middle ear already, the opening in the ear should be enlarged so as to make ample access from below.

If an abscess-cavity has been thoroughly cleansed, drainage is of little value, drainage-tubes being of use only in case of doubt. They

always cause more or less irritation, and are to be avoided if possible. Macewen prefers decalcified-bone tubes for this purpose.

Cerebellar Abscess.

The skull over the mastoid is very thick, but over the inferior occipital fossa it is very thin. Cerebellar abscesses are usually secondary to suppuration in the vicinity of the sigmoid sinus, and are often accompanied by thrombosis of that vessel. Macewen recommends to expose the sigmoid groove first, with the view of ascertaining the condition of its sinus, which will generally be found covered by granulation tissue, and which should be removed along with extradural pus. The general description above given will apply to cerebellar abscesses. During operations upon these it occasionally happens that respiratory difficulties are experienced. These should hurry the operation, and it may be well to alter the position of the patient's head, by which sometimes improvement in breathing is effected. Macewen records two cases during which artificial respiration was maintained—in one case for twenty-four hours, in the other for six.

Frontal Abscesses.

These may be opened either from the front or from the temporal region. Those situated in the posterior part of the frontal lobes are nearest to the surface of the temporal bone. The frontal sinus should be avoided unless it be involved in the lesion. Infection proceeding through the ethmoid may cause abscess near the middle line of the frontal, and trephining through the frontal sinus might better serve for its discovery.[1]

Operations upon the Sinuses.

For exposure of the sigmoid sinus the incision should extend from the tip of the mastoid process over its prominence to the posterior root of the zygoma. The soft tissues and the periosteum should be reflected in one piece. At the upper extremity of this incision the parieto-squamo-mastoid junction is to be exposed (this being the anterior extremity of the parieto-mastoid suture, and not the asterion). From this junction a line drawn to the tip of the mastoid gives the course of the sinus. This usually will lie over its centre, but may mark its posterior border, or possibly, on the left side, its anterior border. The opening now should be made on the level of the bony meatus with its posterior margin touching this line. The sinus may be a quarter of an inch, but possibly only one-twelfth of an inch, from the bone-surface, being much more superficial than the antrum. The asterion corresponds to the union of the lateral and sigmoid sinuses, while the junction above mentioned corresponds to the union of the sigmoid and the superior petrosal; and slightly below this point is the vein of the sigmoid sinus with its convexity forward. In the adult a

[1] The frontal sinuses are rudimentary in infants, small in children, and begin to increase about puberty. They are usually divided by a septum, which is often imperfect.

vertical line half an inch behind the posterior osseous wall of the meatus will usually indicate the middle of the anterior convexity of the sigmoid sinus. This is best opened into with the burr of a surgical engine, although other instruments may be used in case of necessity.

In the course of operations necessitated by ear disease the sinus is usually exposed after the antrum has been opened, in which case the plate of bone between the antrum and the sinus, which so frequently contains channels of infection, is to be removed by the same means. The posterior wall of the antrum being exposed, the bone is opened behind it for half an inch horizontally. If in opening the sigmoid groove granulation tissue from the dura cover the sinus and there be oozing of pus, considerable caution must be observed lest the sinus may be opened too early, before the surgeon is ready for it. If, now, he considers it advisable to open this channel, fully a vertical inch of it ought to be exposed, in order to facilitate the operation and the necessary after-treatment. Diseased bone should, of course, be removed wherever it be met with during these procedures. The space between the groove and the sinus should likewise be thoroughly disinfected, and granulation tissue should be first investigated with a probe, since it may surround a sinus communicating with the cerebellum and an abscess therein. If there be no sinus, the tissue should be removed at all events.

The sinus being incised and its contents cleaned out, it should be filled with some antiseptic powder and lightly packed, its walls being folded in so as to obliterate its lumen. Should hemorrhage occur after opening it, it will not be difficult to arrest the same by a closer packing after detaching a portion of its external wall and crowding it in to help obliterate its cavity.

Air-embolism during these manipulations is not, for the most part, to be feared, although it may possibly occur, and care should of course be exercised to prevent it. To this end it is better to remove débris with a small spoon than by means of the irrigating stream. Packing is a much safer method of occlusion than attempts at ligation.

Ligation of the internal jugular, with incision above the ligature and through-and-through irrigation, has been successfully practised by a number of operators when the infected thrombus extends down into this vessel. While this is not to be done thoughtlessly, it is, nevertheless, a proceeding of great value in certain cases. It is called for when the thrombus has undergone disintegration and when the jugular vein is evidently involved, as can be made out by feeling the same as a cord-like mass in the neck. If one can foresee that this is to be done at all events, it will be wise to operate upon the vein first. This vein, however, is not the only channel of communication between the sigmoid sinus and the lungs, and, in spite of careful work performed upon it, infection may yet reach the lungs by other routes. By occlusion or ligation of the jugular vein the flow of venous blood is reversed, and considerable of what would escape by it finds exit through the anterior and posterior condyloid veins and the occipital sinus.

Two or three other general hints may be given at this point. It is at all times, during the course of these operations upon the ear, and particularly before exposure of the sigmoid sinus, well to carefully examine the mastoid vein, which runs in the groove between the squamous

and the occipital bone, since if there be pus in the sigmoid groove it will work its way out along this vein, where it may be detected externally and where its recognition will give important information. By palpation, as well as by inspection of the sinus before it be opened, one may reach valuable conclusions as to the absence or presence of pus. Keen has well said: "There is nothing outside the sinus so dangerous as the pus inside;" which epigramatic statement may be of great value to the operator if he will remember it at this time. If blood escape freely from the sinus, it does not contain such clot as to necessitate opening it further, while if infectious clot be present, there will be no bleeding, and it may be cleaned out until hemorrhage is free. There are cases on record in which not only was the sinus thus cleaned, but in which even sloughing portions of the sinus-walls have escaped, and yet with recovery. In some of the cases where one is most anxious to attack the jugular vein it will be found with considerable difficulty, being surrounded by more or less inflammatory tissue. This vein must be tied below the termination of the clot, even below the clavicle if necessary, and it may be plugged or drained afterward.

(For more elaborate directions see especially Macewen's *Pyogenic Infective Diseases of the Brain and Spinal Cord*, 1893, and Forselles' *Die durch eitrig Mittelohrentzündung verursachte Lateralsinus-Thrombose*, 1893.)

Operation for Meningitis.—At another point in this article (p. 666) I have referred to an excellent paper by S. W. Gross on opening and drainage in cases of traumatic meningitis. It must have occurred to many that the element of traumatism is of itself not one which should influence choice of operation, but that there may be even more opportunity for effective drainage in cases of non-traumatic meningitis than in those complicated by injury. There is surgically no reason why every suppurating cerebral cavity should not be opened, the only objection here being that an opening in the skull is necessary. Whether the time may ever come when cases of epidemic cerebro-spinal meningitis are subjected to surgical procedures for this purpose, one may not clearly foresee, but there certainly is good reason for attacking cases which lack the epidemic features, although it may require some hardihood to inaugurate this as a general practice. But no advanced surgeon of to-day will deny the propriety of operation in those instances where compression-symptoms are produced by suppurative meningitis, either without or after previous injury; and it would seem to me eminently proper to subject all head-injuries in which there has been no fracture, but in which, either early or late, there develop dangerous cerebral compression-symptoms, to exploratory trephining and drainage. In fact, there is already sufficient evidence on record to justify these procedures. Ruth[1] has reported several cases of this character. Probably the best point for operation in order that the cavity may be properly drained is below the superior curved line of the occiput or else just above the superior border of the posterior third of the zygoma. The arachnoid space must, of course, be opened. Lanphear has suggested also opening this space near the cervical region, where he has seen much more abundant discharge. So long as the fluid which may escape be sero-purulent, one opening may

[1] *Kansas City Medical Index*, Oct., 1893.

suffice. Should it, however, become quite purulent or even thicker, a single opening will not be sufficient; at least two will be required, with irrigation. The openings for this purpose may be small, and the fluid must also be introduced very slowly—perhaps allowed to trickle or find its own way out. Should it be necessary to open the visceral layer of the arachnoid, this may be done over the fissure of Sylvius, since the greatest amount of exudation takes place along the most vascular areas. Lanphear states that experiments upon the cadaver show that blood passes quite readily from an anterior to a posterior opening.

Advantage may also be taken of a suggestion by Dr. Souchon of New Orleans, that for purposes of exploration, either of the marginal cavity or the deeper areas, a large opening—to which many object—is not necessary; but that, having selected the point where one will explore, a very trifling opening in the scalp with the use of a bone-drill, its point carefully guarded, will make sufficient opening in the skull, so that the hypodermic or other aspirating needle may be introduced at as many points as one chooses thus to attack. It seems to the writer also that openings of this kind made at several points could be well utilized in certain cases of infectious meningitis.[1]

Surgical Treatment of Microcephaly and other Arrests of Intracranial Development.

Within the past few years the attention of surgeons has been directed, mainly at first through the writings of Lannelongue, to the surgical treatment of imbecility, idiocy, and allied conditions in young children. In order to approach the surgical aspects of these cases with proper precaution it is necessary to consider briefly the causes which underlie these conditions. Among these we will mention, without respect to anything except the convenience of classification, the following conditions, mostly mentioned in the papers of L. C. Gray[2] and of Jacobi:[3]

1. Chronic encephalitis, diffused or circumscribed, frequently syphilitic.
2. Diffuse disease of blood-vessels, usually due to hereditary syphilis.
3. Arrest of vascular development of the cortex.
4. Inequality of the hemispheres.
5. Inequality of cortical portion on the two sides.
6. Defect of the third frontal convolution and island of Reil.
7. Meningitis and meningo-encephalitis, with perhaps thickening and adhesion of pia, such as may occur after forceps delivery or other injuries.
8. Cephalhæmatoma internum.
9. Spontaneous hemorrhages (either diffuse or local).
10. Embolism from heart disease.
11. Injuries of various kinds.
12. Hydrocephalus internus.
13. Myxœdema.

[1] *Vide* Ricketts, "The Removal by Trephining of Fluid in Acute Cerebral Meningitis," *Internat. Med. Mag.*, Dec., 1894, p. 822.
[2] *Am. Journ. Med. Sci.*, June, 1893.
[3] *Med. Rec.*, May 19, 1894.

14. Premature ossification of the skull.
15. Porencephalitis.

This last condition is so named by Heschl. It implies certain molecular changes in the brain which lead to disappearance of tissue, the loss in amount being sufficient only to cause a very small cavity; at least this is the common condition, although possibly an entire convolution, or even a hemisphere, may disappear in this way. As the nerve-tissue disappears there is usually more or less connective-tissue proliferation, by which a partial substitution of volume may be made. Of the other conditions above mentioned, we may say that the meningitis may be epidemic, either infectious or traumatic, and may be primary or secondary. There is a special type of meningo-encephalitis which begins in the pia and extends gradually throughout the hemispheres even to the base, which is characterized by cellular infiltration and sclerosis, by minute hemorrhages, and, finally, by atrophy, or very rarely by hypertrophy, of the affected convolutions.

The injuries which produce mental defect occur, for the most part, at the period of birth. Hemorrhage in infants or children is usually the result of injury either at birth or later, which may be cortical or occur quite deeply. If deep, the clot thus formed frequently leads to the formation of cysts.

The idea of premature ossification was advocated so far back as 1851 by Virchow in a memoir upon cretinism, and has since been discussed by many writers, including Vogt, Broca, and Gudden. In this memoir Virchow laid down the dictum that cerebral function depends upon the size and symmetry of the brain; which probably still holds good. While it is possible that a normal brain may be locked up in an abnormally small skull by premature closure of fontanelles and sutures, this is not a constant condition, since in not a few instances the possession of a fair intellect is noted in those having abnormally small heads. The appearance of teeth in the upper jaw first, instead of in the lower, is an almost constant symptom in those cases in which the fontanelles have prematurely closed; and it is worth while to investigate the history of each little patient in order to learn whether this phenomenon had been noted. It is stated that the more unilateral the symptoms, the greater is the probability of complication by brain-disease with premature ossification.

Myxœdema, sclerosis, porencephalon, or any marked disease of the cerebral tissue is sufficient in growing infants to cause arrest of cerebral development, which may be followed by arrest of that of the skull, the former being the prior and determining cause. It is generally accepted that porencephalon, chronic inflammatory lesions, and myxœdematous conditions in young children are incapable of complete diagnosis. To be sure, this may be arrived at sometimes by exclusion, but certainly not always. Porencephalon may not commence until the earlier years of infancy or childhood, and it certainly is not attended by much reflex disturbance. By this fact alone it may be distinguished from some of the other conditions. Myxœdema is recognizable by signs which may be noted in other parts of the body rather than about the head. Tuberous hypertrophy is rare and unrecognizable. Meningo-encephalitis gives rise to early signs of cerebral disturbance, and is difficult of recognition,

especially after these subside. If in a given case of idiocy we can obtain a sufficiently reliable history, so that we can exclude meningitis, hemorrhage, and myxœdema, we may have to decide as between porencephalon, which will usually cause more or less disturbance of motion and sensation, and perhaps premature ossification. All of these conditions are likely to cause such organic disturbance as shall show itself by mutism, blindness, motor paralysis, and convulsions or contractions of a single limb. Providing that these symptoms can be excluded, a diagnosis of primary premature ossification is more likely, and here it is reasonable to hold that the pressure of a non-expanding skull upon an expanding brain is sufficient to cause cerebral irritation, as shown by strabismus, general convulsions, uncertainty of gait, contractures, violent temper, involuntary discharges, and various unclassifiable muscular movements. That some cases of premature ossification, or at least those so diagnosed, may contain surprises is shown by a case reported by Wyeth, where the frontal bone on one side was found to be one inch thick, and on subsequent operation, some two months later, upon the other side the same condition was found there.

By Vogt it has been held that many cases of microcephalus might be regarded as manifestations of atavism. Typical microcephalic brains contain scarcely more than half of the due proportion of cerebellum, and, although in general construction they follow ordinary types, it appears often that the convolutions are defectively mapped out, the fissures between them not being sufficiently deep. Some information may be gleaned in these cases by noting whether the face also is disproportionately small. It is of course well known that hemorrhages inside of the cranium result in more or less atrophy, while there may be concomitant pathological thickening of the dura or of the skull. Peterson and Fischer have shown that cerebral atrophy of infants in the motor area is followed by more or less depression in the skull lying over the affected part of the brain. Starr[1] has made a selected study of 343 cases of sclerotic atrophy, whose causes were grouped about as follows:

Porencephalus	132
General or local sclerosis	97
Developmental faults	32
Defect caused by embolism or thrombosis	23
Meningo-encephalitis	21
Cysts	14
Hemorrhages	18
Hydrocephalus internus	5
Unilateral " "	1

(Kundrat has recently affirmed that laceration of the veins entering the sinuses is a cause of hemorrhages during delivery.)

Starr has made a suggestion, moreover, that when operation is undertaken it would be well to explore the area beneath the exposed dura, in order to ascertain whether a cavity exists beneath this opening or not, and, if there be such a cavity, to avoid opening the dura, lest its evacuation should result in death.

A good many writers on the subject of craniotomy for idiocy have

[1] *Med. Rec.*, Jan. 13, 1892.

laid no little stress upon Bourneville's classification of idiocy, which, as enlarged upon by Lacquet,[1] is as follows:

1. Myxœdematous idiocy;
2. Microcephalus;
3. Hydrocephalus;
4. Porencephalus;
5. That produced by arrest of development;
6. By hypertrophic sclerosis;
7. By atrophic sclerosis;
8. By meningitis or meningo-encephalitis.

Bourneville has been a constant opponent of operation, since he maintains that alterations in the shape of the skull are the results, and not the causes, of brain-lesions, and that the brain which is not normally developed will not be covered by normal skull. Before the Academy of Sciences he reported that the skulls of 350 idiots showed no premature closure of sutures, and that it was impossible during life to make out conditions which could be considered exact indications for operation. It must, however, be stated that Bourneville's investigations and conclusions were drawn from all kinds of idiots, and that no one has yet claimed or suggested that operation be indicated in all these cases. Gray has shown that local synostosis is met with in children as a positively pathological condition, since normally it does not occur until the fortieth or fiftieth year of life, while Sappey has shown that complete obliteration of sutures rarely occurs before the eightieth year. Consequently, Bourneville's objections have less weight than they might otherwise have. Akerman believes that there have come from so many different sources reports of positive improvement after operation that theoretical considerations must take a secondary place; and he is equally positive that a number of these patients who were previously aphasic have learned to talk; so also with the functions of sight and other special senses there has been great improvement. Ransohoff had a patient who, three and a half months after operation, began to follow persons and objects with the eye, while in a case of Morrison this occurred still earlier. Miller had one case in which optic neuritis seemed present on both sides, and yet in which sight positively improved after the operation. Local pareses have also disappeared. In a case of Anger's the athetosis disappeared, while Barr found that in one of these cases the spastic paresis and tremor of the hand, which were a part of the symptoms, vanished, so that the patient could even find and pick up a needle. Horsley has seen a kind of spastic wry-neck relieved by operation in one of his cases. Many writers have noted disappearance of chronic cramps of the extremities. Epileptiform attacks have also diminished in frequency or been easily checked. One of the things in which improvement has been especially noticed has been mental irritability, with more or less continuous crying.

Another of the principal opponents of operation has been Jacobi,[2] but his opposition is not well taken, and it is quite evident that in selecting the cases upon which he should base such opposition he has

[1] "Contribution à l'Étude de l'Obliteration des Sutures des Crânes chez les Idiots," *Thèse*, Paris, 1892.

[2] See *Med. Rec.*, May 19, 1894.

not included a number of those which were favorable to it, since, while he had at hand the report of 5 cases of the writer's, he saw fit to use only 1, which was the most unfavorable of them all.

Binnie[1] holds that we have given too little attention to cases of imbecility in which microcephalus is absent or not marked. He has operated on two such cases, once with success. His fatal case died within a few hours, death being preceded by pyrexia, which he thinks may have been due to injury of the supposititious thermotaxic centres spoken of by Horsley and others. His own conclusions as to such centres are fortified by observation that in various forms of paralysis due to cortical lesions the temperature of the paralyzed area is often higher than that of the similar area on the opposite side. Binnie speaks also of the possibility of fatty destruction of cerebral tissue in cases of atrophic idiocy, and thinks that these are cases which one cannot arrest by operation. He alludes to the fact, also spoken of by Lanphear, that in some of these cases when the skull is first opened there is no visible cerebral pulsation, but that this appears a little later; which, of course, is extremely suggestive, and would imply that something had been removed or remedied which was interfering with development. He refers also to two cases spoken of by Griffith and by Parkhill where, after opening the dura, a great quantity of cerebro-spinal fluid escaped, where the whole hemisphere seemed to collapse, and death speedily resulted. In these, of course, there was a widely-dilated lateral ventricle beneath. These cases are essentially hydrocephalus without distention of the head. He suggests that in such cases the fluid be gradually removed with the hypodermic needle and the dura not opened. Of the value of the removal of a *wide* strip of bone, if any, he gives important proof in that in one case, in which after the first operation no improvement resulted, he operated a second time on the same side after but a few weeks' interval; at which time it was found that much of the opening formerly made had been filled up by new bone, showing that a defect even one-half inch in width can soon be obliterated.

The most elaborate article which has appeared in English upon this subject is on "Craniotomy in Microcephalus" by Karl Beck.[2] Here the interested reader may find tables of cases with results, and reports of several individual instances. From Beck's studies it would appear that of 72 operations by various operators, 12 have died, a mortality of nearly 17 per cent. while in Lannelongue's individual cases, 25 in number, only 1 died, or 4 per cent. These figures, of course, have only a relative value, and at least 10 cases which the writer of this article could add to the above table would lower the percentage of mortality quite appreciably. The principal dangers of the operation are shock, hemorrhage, and infection. Shock is to be reduced to a minimum by avoidance of the use of chisel and mallet, which should be abandoned in this kind of surgery. The operation must be performed in the shortest possible time, while hot applications to the head and inversion of the patient may be effectual in restoring to duty a prostrated heart. Gaster lost a case by hemorrhage from the diploë, which ordinarily does not bleed very much. Hemorrhage from a wounded sinus is, of course,

[1] *Annals of Surgery*, April 1, 1894, p. 453.
[2] *Journ. of Am. Med. Asso'n*, Oct. and Nov., 1894.

serious, but may be checked by packing with gauze, as related elsewhere in this article. Rigid antiseptic precautions will probably prevent infection. The writer's own experience proves how easily the bone may be separated across the longitudinal sinus without any fear of damage to this channel.

It should always be fully explained to parents and anxious friends that immediate improvement is scarcely ever to be expected—that whatever may come in this direction must come very slowly and with the gradual development of the child. To this I may add that at least one of my own cases responded with a promptitude of cessation of convulsions and of obedience to spoken commands which astonished all who knew of the case. Beck's conclusions are worth repeating here verbatim:

"1. Craniectomy is a justifiable operation, and apt to be successful in the treatment of microcephaly with idiocy.

"2. The success depends on the kind of microcephaly and the degree of the idiocy.

"3. Acquired and late forms give a better prognosis than congenital forms.

"4. The danger of the operation is not very great.

"5. The operation ought to be quite extensive—that is, the incision in the skull large enough to permit dilatation—and the circular method of Gersuny ought to be given a trial.

"6. The patients must be given a thorough pedagogic treatment afterward.

"7. Cases ought to be followed up for years and reported from time to time."

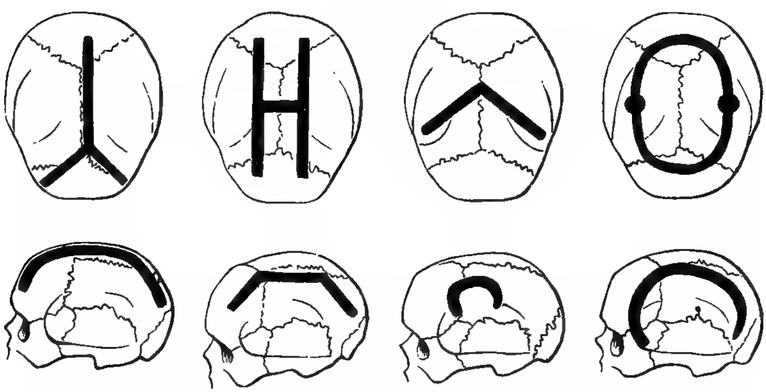
Operation.—To Fuller of Grand Rapids, Mich., is probably due the credit of performing the first operation done for this purpose.[1] Lannelongue of Paris is generally credited, however, with its introduction as a recognized surgical procedure,[2] since in the summer of 1891 he reported to the Academy of Medicine in Paris two cases in which he had removed pieces of the cranial vault, upon the theory that there had been a blighted development due to early closure of the natural openings. He described this at that time as "linear craniotomy." During the following year he reported upon 25 similar cases. Although none of them were microcephalous, they were, in his own words, "backward children and young people presenting motor and psychical disturbances, with or without epileptiform seizures." By 1893 the operation had found numerous adherents all over the world.

There are, in effect, three different methods of practising this operation: linear craniotomy, or, as Keen would prefer to call it, "craniectomy;" craniotomy *à lambeau;* and circular craniotomy. Which of these is to be selected in the given case must depend largely upon the particular circumstances. If the intention be to permit expansion of the skull in a lateral direction, linear craniotomy, done first on one side and then on the other, from the region of the occipital protuberance well forward toward the root of the nose, the interval between the two being at least several weeks, offers excellent prospects. If there be cranial asymmetry and restricted development over the motor areas, the

[1] *Chicago Med. Rec.*, vol. iii. p. 119. [2] *Congrès des Chirurgiens français*, 1891.

writer prefers either to lay up a large lateral flap of bone and soft parts together, or to make in older cases an osteoplastic resection, the area thus elevated being quite extensive and including all the covering of the motor area. If the frontal region be defective, the craniotomy *à lambeau* or the Y-shaped section can be adopted. In yet other cases, where the entire roof of the skull seems to be at fault, Gersuny's circular craniotomy can be employed. Whichever be chosen, the writer would advise to make a small trephine opening as a starting-point, and then with cutting forceps (rongeur) to cut away in the desired direction a wide swath of bone, taking periosteum and bone together, sparing of course the dura. In order to permit of this and to make the operation as bloodless as possible, it is best usually to surround the skull with an elastic tourniquet or rubber tube, protecting the ears, and taking precaution that the rubber does not slip down over the eyes. The skin is incised on a line a half inch or so from that which it is expected to follow with the forceps, in such a way that when the parts are brought together the skin-incision shall not be directly over the defect in the bone. After an experience of a dozen or more cases the writer has found the forceps above spoken of more satisfactory than any other method, although he has tried both chisel and various revolving saws, which are much more likely to lacerate the dura and which require really more time. The skull of a child of two can usually be sufficiently divided—or at least as extensively as should be thought of in one ope-

FIG. 426.



Lines of removal of bone as practised by the author, by Lannelongue, and by others.

ration—within fifteen minutes after it be begun. The experience of all operators demands that if this is to be an opening for permanent effect, a wide area of bone must be removed, and no hesitation need be felt in making it nearer an inch than a half inch. I have repeatedly laid up an omega-shaped flap of bone, periosteum, and soft parts in the lateral region of the skull, its base corresponding rudely to the ear and the extremity of its angle reaching almost to the middle line. If a quantity of bone be removed with this, it will be a sufficiently long time before it can be reproduced, so that the skull shall have opportunity for expansion. It certainly is better to do what is required in three sittings and

have the patient promptly recover from each, rather than to overdo, and lose or almost lose the patient at the first operation. My own experience has been that even puny children stand two or three of these short operations very well. I believe, however, most thoroughly in the wisdom of preparation for this or any other procedure, and have kept more than one patient waiting for three or four months, during which time I was building up his system with compound syrup of hypophosphites and the best of nutrients and tonics. The first case in which I practised the Y-shaped section of the skull was one in which I performed it, as a measure original so far as I was concerned, by a line extending near the occipital protuberance forward to the junction with the frontal, from which point a strip of bone was excised toward each external angle of the orbits, in such a way that the frontal bone had a triangular piece loosened from it whose base corresponded to the superciliary ridges. This child was an absolute idiot when operated on; a year later it was in school.

The circular craniotomy already alluded to was suggested by Gersuny,[1] who advised a complete loosening of the vertex of the skull by a circular cut, leaving, of course, sufficient uninjured soft parts to maintain nourishment of the bone. While there is no question but what much easier and speedier expansion would be permitted by incising the dura, the majority of operators hold that it is not wise, except in the presence of some clear reason for the same. Even if the dura be opened, it would be usually wise to close it again with catgut. Drainage of the subdural space is certainly in most instances unwise. If the operation be performed as above suggested and the skin-wound be closed before the tourniquet be removed, providing particularly that hot compresses have been applied for a few moments, or a spray of 5 per cent. antipyrine solution directed upon the parts to check oozing,[2] it will be found that the dressings can be applied immediately, with the loss of less perhaps than an ounce of blood; all of which is inestimably to the child's advantage, since, in some cases at least, pyrexia seems to be due to loss of blood.[3]

The skin may be brought together with continuous catgut sutures, and the wound will usually be found to heal under one dressing. Dumont has also suggested a method of performing circular craniectomy[4] by median incision, detaching the scalp from forehead to occiput, making an opening on either side of the parietal eminence, and cutting through the bone until the vertex is freely movable, its blood-supply coming from the dural vessels. The child on whom he performed this operation nearly died of collapse, and after several days showed marked improvement, cessation of convulsions, etc. Two months later the vertex of the skull was still movable, the incisor teeth had appeared in both jaws, there were signs of increasing intelligence, and no convulsions had occurred.

[1] *Wiener med. Wochenschrift*, 1892. [2] *Med. News*, Dec. 15, 1894, p. 663.

[3] In two or three cases of hyperpyrexia after these or similar severe operations upon little children I have found the happiest and speediest effect followed the hypodermic injection of what is ordinarily regarded as a large dose of tincture of aconite-root. I have given of this 8 or 10 drops, with as much tincture of digitalis in one dose, repeated perhaps once, and have never seen anything but desirable results follow this procedure.

[4] *Correspondenzblatt f. Schweitzer Aertze*, 1893, No. 23, p. 778.

Another method of closing the wound, which in the writer's experience has been of the greatest benefit, is to pack the wound itself with iodoform gauze, which is tucked into the groove cut by the bone forceps, to insert secondary sutures of silk at intervals of two inches, which are tied in bow-knots, and then to apply the dressing outside of this, using a sterilized ointment freely in order to prevent adhesions of dressings. After three or four days the gauze may be easily removed by untying the loose knots of the secondary sutures, which are then utilized for the purpose of making a complete closure of the wound, and are now tied snugly. In fact, for many purposes in connection with surgery of the head this method seems to the writer more exact and successful than any other which he has ever resorted to.

A new trephine and bone-cutter has been described by Wright, and figured in the *International Med. Mag.*, May 4, 1894, p. 262. The appliance consists of a trephine for opening the cranium with a series of cutters revolving at high speed and actuated by the electric or surgical engine.[1]

With regard to the whole matter of surgical interference in cases of defective cerebral development and its cognate affections, it is still so much under advisement and on trial that the writer prefers to refer those who are particularly interested in it to the literature, much of which is summarized in Beck's article, before alluded to, and particularly to the articles by Beck himself;[2] by the writer;[3] by Lanphear;[4] by Keen;[5] by Akerman;[6] by Reboul;[7] and particularly to the monograph by Ceresole.[8]

Protrusion of the Cerebral Membranes.

CEPHALOCELES.

Certain tumors are met with about the skull which are filled with more or less normal cerebral contents, and which present through openings in the cranial bones, which are generally or collectively known as "cephaloceles" or "cerebral herniæ."[9] They are essentially of congenital origin, and their causes pertain to defects of development in early intra-uterine life. Larger has insisted that the congenital cephaloceles should be regarded not as herniæ, but as eccyeses. Their seat is, for the most part, on the middle line at either one or the other extremity of the skull, and occipital cephaloceles connect with the cranial cavity by defect in the underlying bone, which may be at a level above or beneath the tentorium. Sometimes, indeed, this defect is really an extension of the membrane.

[1] See also Tillmanns (*Centralblt. f. Chir.*, 1894, July 28, p. 29), who holds that the operation has a very limited sphere of usefulness. He thinks the incision through the soft parts in the bone should be made at different levels, and the periosteum should be completely removed over the bone to be taken away. We would remove bone over an area at least 12 to 14 cm. in length, and at least 1 cm. wide. It should be removed parallel to the longitudinal sinus.

[2] *Loc. cit.* [3] *Med. News*, 1892. [4] *International Clinics*, 3d Ser., vol. ii., 1893, p. 227.

[5] *Am. Journ. Med. Sci.*, vol. ci., 1891, p. 847, and *Med. News*, Nov. 29, 1890.

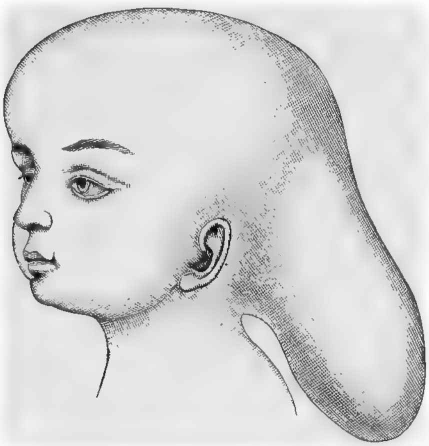
[6] *Sammlung klin. Vorträge*, new series, No. 90, 1894.

[7] *Arch. Prov. de Chir.*, vol. ii. p. 370.

[8] *Contribution à l'Étude de la Craniectomie dans la Microcephalie et l'Idiot.*

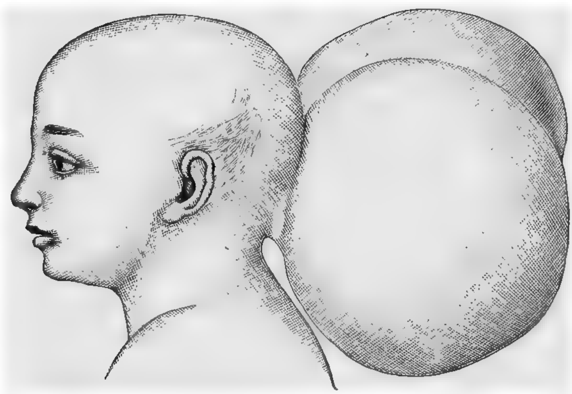
[9] Christern, "Ueber Meningocele spuria traumatica," *Beiträge zur klin. Chirurgie*, vii. 244.

FIG. 427.



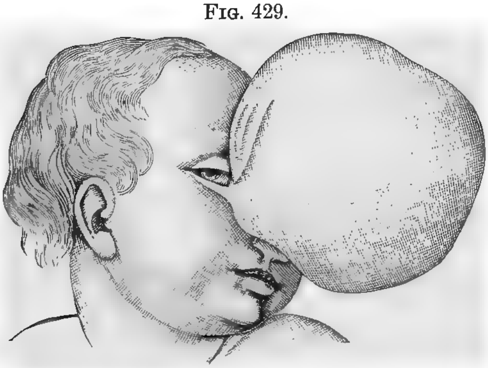
Occipital cephalocele of peculiar form (Bruns).

FIG. 428.



Occipital meningocele (Bruns).

FIG. 429.

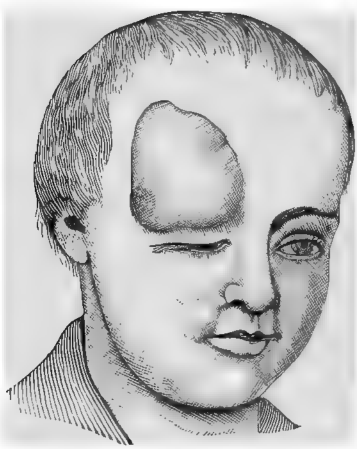


Sincipital cephalocele (Bruns).

In some of these cases the arches of the atlas and possibly of other cervical vertebræ are also lacking. Occipital cephaloceles are known as inferior when they occur below the occipital spine, and superior when they lie above it or are laterally disposed. Many of them reach a considerable size on account of the enlarged defect in the occipital bone. Those which appear anteriorly are known as sincipital cephaloceles, and are met most often at the root of the nose, through which they may reach to the forehead or into the orbit or the nasal cavity. They communicate with the cranial cavity by the bony canal, usually medially placed, in the construction of which both frontal and ethmoid bones are concerned. This canal may open between the lowest part of the two halves of the frontal bone directly into the nasal cavity. In these cases the tumor is to be known as "naso-frontal cephalocele."

In other cases the tumor will lie between the ethmoid on one side and the frontal and nasal bones on the other, and then will be known as "naso-ethmoidal," in which case it will sink downward and backward and appear between the bony and cartilaginous parts of the nose. Clar has reported one such case, in which a tumor of this kind penetrated into the orbit because of defect of the lachrymal bone and frontal process of the upper jaw. Such a tumor would probably be known as "naso-orbital." It is true that while there are three different paths open for these growths, they are not always readily distinguished one from another. In other instances anomalous growths of this kind may also occur, as, for instance, through the parietal bone, etc. In the literature of the past many of these cases have been spoken of as dermoid cysts; others have been regarded as malformations of the skull, although a part of the brain has been found in some of them in the tumor itself. These are perhaps to be regarded less as cephaloceles proper than as teratological curiosities.[1]

FIG. 430.



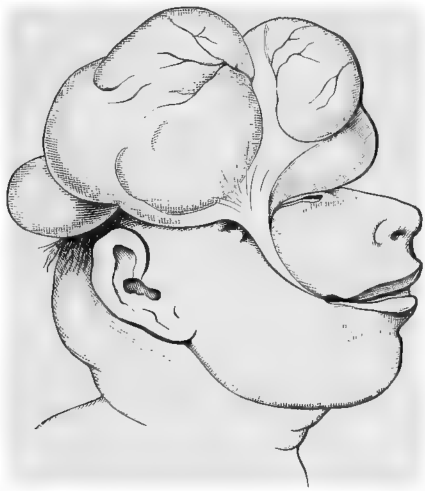
Orbital cephalocele (Bruns).

Finally, another group of cephaloceles are those which escape through the base of the skull. The most common of these are those which sink between the ethmoid and the sphenoid into the naso-pharyngeal cavity, or which hang in the mouth from the fissured palate, and which are known as spheno-pharyngeal cephaloceles. Others penetrate into the orbit through the orbital fissure or into the spheno-maxillary fossa, and are designated as "spheno-orbital" and "spheno-maxillary" cephaloceles. So far as the frequency of these various groups is concerned, Larger finds that of 85 cephaloceles 44 were occipital and 41 sincipital, the naso-frontal variety being the most common of the latter. The canals through

[1] *Vide* Lücke, "Ein Fall von Meningocele orbitalis," *Deutsche Zeitschft. f. Chir.*, xxxii. 582; also Guibert, *Contribution à l'Étude anatomo-pathologique de l'Encéphalocèle congénitale*, Lille, 1894.

which they escape from the cranium are formed partly of bone, partly of fibrous tissue, and have smooth surfaces. The size of the opening is

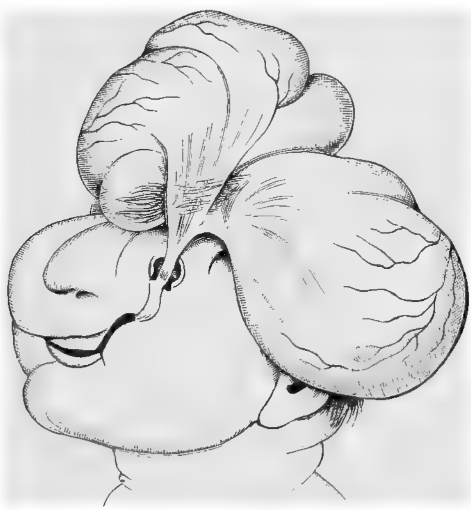
FIG. 431.



Congenital fissure of mouth and face, coloboma of lids, almost complete *exencephalus*—right side (Lannelongue—*Kystes congénitaux*).

usually smaller than the circumference of the base of the tumor. These tumors vary in size from that of a pea to that of the patient's head. For

FIG. 432.



The same as Fig. 431—left side.

the most part they have an even shape and surface, yet some are divided into parts by folds or constrictions. Many of them are pedunculated,

having a neck much smaller than the growth itself, while others have a broad basis and are widely spread out upon the skull. In many cases their surfaces are reddened and are vascular. In fact, they may contain redundant vessels, and be at first mistaken for angiomata, this being particularly the case with the sincipital growths. Sometimes the skin-covering is so metamorphosed that they appear to be covered with mucous membrane or by granulating surfaces. At other times the surface appears to be composed of cicatricial tissue. Beneath the integument covering such growths lies a fibrous membrane corresponding to the sac of a hernia, which is practically always composed of a continuation of dural tissue. Small cystic cavities are often found beneath the overlying skin and the main sac. At other times lipomata are found snugly adherent to the dura itself. Again, the membrane may be so much thickened in places as to be studded with fibromatous growths, while its inner surface is divided by fibrous partitions, these partitions in certain cases being relics of a distorted tentorium or falx. In some cases the sac contains fluid; in other instances its contents are almost entirely brain-tissue. In the former case we have to deal with meningocele; in the latter, with encephalocele proper. In the latter case there are frequently abnormal accompaniments, of which the most common is a hydrocephalic distention of a ventricle. Along with the cephaloceles in general we often meet with developmental defects, such as microcephalus, etc. In some cases the two sides of the skull are asymmetrically developed, and in many cases there are other deformites, such as club-foot, herniæ, etc.[1]

Cephaloceles have an elastic feeling, and many of them show an exquisite fluctuation; sometimes with the sense of touch we can recognize both their fluid and solid contents when they have both. When the sac is thin and contains much fluid it is translucent. By pressure cephaloceles can be reduced in size, in which instance only can the entire contents be pressed within the skull. Pressure causes in many instances, if not in all, brain-symptoms. When moderate, the children are restless and cry; when pressure is severe, they shut the eyes, relax the limbs, and may vomit or become convulsive. Many children cannot lie upon this tumor without becoming restless. When the protrusions are large they frequently hang upon the side of the head or by their weight give the head an abnormal position. The border of the bony opening can seldom be felt until the size of the tumor has been somewhat reduced by pressure. By palpation externally it is frequently possible to detect pulsations of the brain. When patients cry, cough, sneeze, or make any violent straining efforts, the tumor becomes larger and more distended, its covering more stretched and vascularized, and usually more blue, owing to venous stasis. During quiet sleep the tumor is reduced in size or at least in its tension.[2]

What has been said above pertains with equal truth to the two general varieties of cephaloceles which have been described under the particular names of "*meningoceles*" and "*encephaloceles*." The former

[1] *Vide* Fenger, "Basal Hernias of the Brain," *Am. Journ. Med. Sci.*, Jan., 1895, p. 1 (with bibliography).

[2] Horsley recommends the electric current in order to recognize the presence of brain-substance inside of a cephalocele. A differential diagnosis is difficult. The examination by means of the electric current, as thus suggested, may shed some light upon the character of the contents of the tumor.

contain fluid alone, and the contents of the sac are formed primarily from the outer membranous investment of the brain, while in the latter case there is more or less actual protrusion of brain-substance beyond the normal limits of the cranial cavity.

Meningocele is most often occipital in location; next to this, sincipital. Naso-frontal, naso-orbital, and naso-ethmoidal varieties have been described by various authors, as well as the lateral formations and others which are irregular and unclassified. The sac contains a serous or cerebrospinal fluid. In many cases the brain appears absolutely normal, or shows at least very trifling variation from the normal. In other cases, however,

FIG. 433.

Sincipital (fronto-nasal) cephalocele: case of the author's.

developmental defects have been observed, such as microcephalus, porencephalus, hydrocephalus, etc. The base of a meningocele is usually broad, and but seldom pedunculated. The tension of the contained fluid is easily influenced by efforts on the part of the patient, such as crying, coughing, etc. On the other hand, brain-symptoms are less likely to be produced by pressure than in the case of encephaloceles. During sleep the tumor is reduced in size.

A large proportion of patients with this congenital defect die soon after birth, often of marasmus. Occasionally the presence of the tumor is the cause of death during delivery or it requires some mutilating obstetric operation. On the other hand, patients with well-developed brains, having congenital meningocele, often develop well in every other respect, although the tumor may grow relatively rapidly or slowly, and thus extend the area involved. Not infrequently the sac gives way spontaneously, and the fluid is evacuated either slowly or rapidly. This practically always gives rise to purulent meningitis, of which patients die. The principal danger, then, pertaining to meningocele is spontaneous and accidental rupture of the sac, although, as a rule, these tumors grow slowly or present such thickening of their surroundings as to be reasonably protected.

ENCEPHALOCELES.

Encephaloceles are more commonly met with than meningoceles of pure type. These also present most commonly in the occipital region. That portion of the brain which is found within the sac of the tumor appears to be more or less separated from the balance by its pedicle. Often that portion contained within the tumor is itself merely a dilated brain-cavity of some kind, and consists of a thin area of brain and

Fig. 434.

Occipital cephalocele (original in author's possession).

enclosing fluid communicating with the ventricle—in other words, a combination of encephalocele and a ventricular form of hydrocephalus. Only a small portion of brain-hernia of this kind consists of solid brain-substance. Thus we have a division of encephaloceles into two groups —the *cenencephaloceles* and the *hydrencephaloceles.* The hydrencephaloceles constitute tumors of various sizes, found most often in the occipital region, and containing the distended posterior cornua of the lateral ventricle. More seldom they occupy the posterior occipital region, and may then contain a part of the cerebrum with the hydropic fourth ventricle. Some of the largest occipital cephaloceles are, in fact, hydrencephaloceles which contain the occipital lobe of the external cerebellum, and perhaps often the quadrigemina, along with the distended posterior cornua of the lateral ventricle and the dilated fourth ventricle, with the Sylvian aqueduct, already distended with the contained fluid. Sincipital hydrencephaloceles are rare, particularly those of the naso-frontal and naso-ethmoidal varieties. The quantity of fluid thus contained in these tumors is various—from a few ounces to two quarts. Along with the membrane which constitutes the hernial sac are also other partitions, such as the falx, the tentorium, and so on, but usually more or less distorted and deformed. In the sac may also be found the venous sinus pertaining to the membrane and localities primarily involved. That remaining portion of the brain still in its proper cavity shows under these circumstances various deformities and defects. Usually the ventricles are dilated, while the skull itself is occasionally enlarged. As a rule, however, the skull proper is microcephalic, with small fontanelles, the sutures thick, and it is frequently asymmetrical. The tumors show a tendency to slowly enlarge; as a rule, they evince no brain-pulsation and are less likely to be distended by crying, coughing, etc. They are less sensitive to pressure, and compression is less likely

to evoke brain-symptoms than in other forms. The majority of children thus affected die before or during birth; a few of them survive the first weeks of extra-uterine life.

Cenencephaloceles, or simple encephaloceles, occur more often than the previous form. They are oftener found in the sincipital and less often in the occipital region, and constitute, for the most part, tumors with broader bases. They have a peculiar elastic feeling, and when fluid is present between the sac-wall and the brain they may appear translucent. They pulsate more firmly, especially if the patient cry and cough, becoming smaller during sleep, and are more easily reduced in size by pressure. Their coverings appear, for the most part, normal. and are often excoriated or show cicatricial tissue. The skull is, as a rule. very much contracted, and there is a tendency toward microcephalus. Many of these children also often die during or shortly after birth, but a considerable proportion of them develop normally in other respects. The hernial tumors grow but slowly or remain nearly stationary. These children often reach the age of puberty or live still longer. Some of them are deficient in intellectual development, and still others are complete imbeciles. Others, again, show certain defects, such as paresis of one arm, amaurosis of one eye, etc. Individuals with sincipital tumors of this kind, as a rule, live much longer and are more intelligent than those whose tumors are elsewhere located.

The consideration of the **cause** of these anomalies takes us too far from the primary purpose of this treatise, and would lead deeply into the study both of embryology and teratology. It is enough for our present purposes to say that the causes concern the earliest months of intra-uterine life, and may be either internal or external. It is quite possible that the anatomy of the mother may explain some of these cases, as when there is exostosis or protuberance from the pelvis pressing upon the growing head, preventing its proper development and causing absorption of the bone. External causes may be injuries or various other conditions.

A peculiar form of meningocele has been described by Gintrac, Holmes, and others. It is met with only in the occipital region, and consists of a dural sac with a protrusion of the arachnoid, which is filled with fluid and communicates with the fourth ventricle; in fact, it seems often to be a hydropic distention of this ventricle, which, by communication from the foramen of Magendie, is then connected with the arachnoid.

Other rare and peculiar forms, which belong rather to the curiosities of the subject, and are not of sufficient importance to detain us here, have also been described by various authors.

So far as the **diagnosis** is concerned, we must remember, first of all, that these tumors are invariably congenital; next most important is the location of the tumor; next to this come the common signs, such as brain-pulsation, augmentation in size by forced expiration, reduction of the same during quiet breathing, and still more so during sleep, production of signs of brain-irritation by firm or sudden pressure, reducibility of tumor, detection of margin of the bony opening, etc. Of lesser importance are the recognition of certain less constant phenomena, as, for instance, the form and type of the skull, and the existence of micro-

cephalus. Tumors which are too distended to permit of careful examination would better be aseptically tapped with the aspirating needle, after which one may recognize the bony opening through which they project. This may also be done by the passage of a fine clean common needle through the skin and exploring as with a probe. The occipital tumors seldom present any difficulty in diagnosis. Here the hydrencephaloceles are most common, the pure meningoceles less so. The tumor itself fluctuates, and is often translucent, while pulsation and pressure-symptoms usually are wanting. These cases are observed practically always in the new-born, for the children seldom live long after birth. Diagnosis of sincipital encephaloceles is less simple. We may have to do here with cenencephaloceles. Here the bony opening may be so small as to make it difficult of recognition. This is particularly true when the tumors occur about the orbit or at the glabella. These tumors usually pulsate, increase on expiration, diminish during sleep, and are more or less reducible. Such tumors would have to be diagnosed from cysts and other dermoids, also from vascular tumors, which often occur in these localities. A point of great importance would be any coincident deformity of the skull itself. Sometimes the distance between the eyes is considerably increased, while the orbital cavities themselves are reduced in their antero-posterior dimensions, as a result of which the eyes are set far apart and have a peculiar appearance, with some protrusion. Congenital tumors of other regions would rarely be mistaken for cephaloceles if carefully studied, unless they are reducible and show brain-pulsation.

As between the different forms of cephaloceles, the diagnosis is usually not very difficult. The pure meningoceles are found most often in the upper and lower occipital region; they fluctuate and are translucent; their size is influenced as already mentioned; they are easily emptied by puncture and are reduced in size by pressure. The hydrencephaloceles form large, fluctuating, often translucent and often symmetrically-developed tumors, usually located in the occipital region —are not reducible and are but slightly influenced by forced expiration. They are not completely or easily emptied by puncture. They are almost always met with in deformed skulls. The cenencephaloceles are practically the only variety which are ever met with in adult life. They are situated anteriorly for the most part, may have thick walls, fluctuate more or less, and after being emptied by puncture are only partially reduced in size; they pulsate with violent expiration and diminish during sleep, and are usually only slightly reducible.

Prognosis.—The prognosis of encephaloceles is in general unfavorable. Only a small percentage of children born with these tumors live for more than a few weeks. Most rapidly fatal are the hydrencephaloceles, partly because, as a rule, the entire brain is defective. The cenencephaloceles permit the most favorable prognosis, since but few of them by themselves are dangerous to life.

Treatment.—Treatment should, first of all, be directed toward protection against spontaneous rupture of the tumor. This may be done by mechanical protection of some kind with starched bandages or with some plastic material, or in certain instances simply by enveloping the head in cotton. Radical treatment has been tried many

times and in many ways. All sorts of efforts have been made by puncture, incision, ligature, and écrasement, extirpation, and also by injection, none of which have as yet given very favorable results. It happened to Leasure to heal a hydrencephalocele by puncture and compression. The cases in which one most desires to render help are those where the greatest difficulties are present. Many cases of small anterior cenencephaloceles may be left alone, or at least interference may be indefinitely delayed. So far as the remaining forms are concerned, compression, with or without puncture, has given generally the most satisfactory results. Most of these cases present in such a way that on mechanical grounds alone extirpation is in most respects simple and easy of performance; but there are cases in which absolute aseptic precautions are nearly or completely impossible, and these cases, therefore, are bound to succumb from purulent meningitis in a most discouraging way. The ligature has in a few instances been successfully applied. Not a few times as the result of mistaken diagnosis has free incision been made with speedily fatal results. The same is true also of iodine injections. In a general way, we would only say that, while in individual instances radical efforts may give some promise of success, the most satisfactory method has been found to be puncture with a fine needle, repeated as may seem wise, and followed by continuous compression arranged as the ingenuity of the surgeon may best devise.[1] (Bergmann reports two cases of successful operation for encephalocele containing brain-substance performed by Schmitz of St. Petersburg.)

Bergmann recommends operation in cases of sincipital encephalocele, especially the smaller forms, since it is well known that children born with these forms live longer than those afflicted with occipital encephaloceles, several cases having been reported as passing the age of puberty. Larger[2] has reported 10 cases of adults with sincipital encephalocele, 9 of which had preserved their intelligence.[3] Still, all of those who survive do not necessarily escape secondary results. Thus, Volkmann[4] observed in a girl three and a half years old that the eyes turned and protruded. A patient of Muhr, although having reached the forty-second year, had been an epileptic since childhood, and was at that time manifesting progressive insanity.

These tumors are apt to be richly supplied with blood-vessels freely anastomosing, and the skin-covering is usually very delicate, sometimes as thin as a veil. De Rauter has called attention to the peculiarity of

[1] For a successful case of basal cerebral hernia treated by temporary resection of the jaw and fixation of the pedicle, *vide* Fenger, "Basal Hernias of the Brain," *Am. Journ. Med. Sci.*, 1895, January, p. 1.

[2] *Arch. gén.*, Juillet, 1877.

[3] Lindfors has reported a case of a boy, ten months of age, with a large bilobed tumor between the forehead and the nose, both lobes being round, fluctuating, and elastic, the left as large as a chestnut. Exploratory incision showed that they had no communication with each other. From each a thin fluid of a straw-yellow color escaped. Portions of each cyst-wall were found to consist of dense connective tissue. The tumor recurred and was excised. Microscopic examination showed it consisted of normal skin and underlying cavernous tissues, tortuous blood-vessels, and an inner layer of firm, homogeneous connective tissue. There were no nerve-elements present. Tumor probably a pure meningocele of rare bilateral form. Rapid recurrence was due to enormous thickening of the cystic wall and subsequent structural alteration of the growth. Recovery followed the operation (*Upsala lakareförenings forhandlingar*, vol. xxix. 4, p. 219).

[4] *Beiträge*, 1875, p. 261.

absence of the dura at the summit of tumors of spina bifida, as well as at the summit of occipital encephaloceles. At this point we frequently find the soft, succulent structure of the cavernoma; hence the great importance of infiltration of blood and of surface-forming at this point; hence also the necessity for operation.

The cranial defect which permits of sincipital encephaloceles is probably in large measure due to the operative action of amniotic bands or disturbances in the cephalic flexure of the amnion. Morian[1] has studied the relations of oblique facial cleft to the above disturbances. In 34 cases of such clefts brain-anomalies were present in 26; among them, 7 cases of encephalocele and 15 cases in which amniotic adhesions were still visible or demonstrable. It is most probable that the frequent coincidence of such anatomical defects is due to a common etiology. Moreover, sincipital encephaloceles are uniformly placed laterally; even in those which are so large as to apparently occupy a central position this is nevertheless true.

Until very recently extirpation of the projecting walls of brain-substance has been resorted to very seldom, and really only in cases of mistaken diagnosis.[2]

HYDROCEPHALUS.

This term is given to abnormal collections of fluid within the cranial cavity. When the fluid is confined to the ventricles of the brain, which are much dilated to accommodate it, it is known as "hydrocephalus ventriculorum" or "internus;" when outside of the brain, between it and the dura, it is known as "hydrocephalus meningeus" or sometimes "externus." The latter is relatively rare, and the title is usually applied to those cases where the ventricles are not primarily affected. It may be congenital or acquired. When congenital, the cause is usually inseparable from imperfect development of the brain, while the space between the shrunken brain and the cranial wall is filled with fluid. It is sometimes combined with coincident hydrops ventriculorum. The skull itself at the time of beginning trouble may be of natural size or a trifle increased. Most of the children thus affected die soon after delivery, living usually only a few weeks or months, although Bright has reported a case of this kind still living at the age of twenty-nine years. The acquired form is noted in both children and adults.[3]

On autopsy of hydrocephalic children it is quite common to find from 150 c. c. to several hundred c. c. of fluid. The condition is more

[1] *Arbeiten der Chir. klin.*, Berlin, 1887, vol. ii. p. 57.

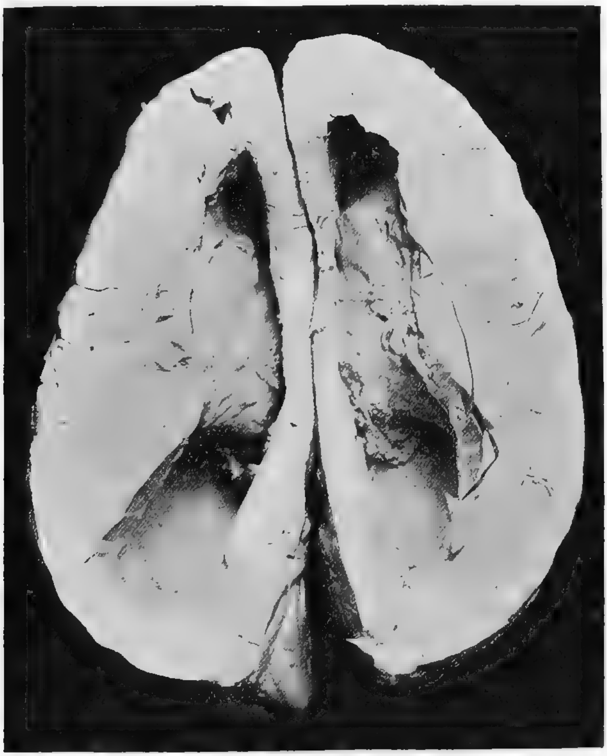
[2] Muscatello (concerning "Congenital Fissures of the Skull and the Spine," *Langenbeck's Archiv*, 47, 162) distinguishes between cephalocystocele and cephalocysto-meningocele, believing in operating upon the former for removal of the sac. Should nerve-substance be spread out upon its inner layer, he would endeavor to return this within the cranial cavity. The most significant contraindication to this treatment is the existence of visual disturbance of higher grade, such as optic atrophy, etc. In the second class of cases the operative method must be somewhat altered. Here the cyst-wall is usually not tensely distended, since most of the blood is collected in the arachnoid cavity, and if any brain-substance be present it causes less disturbance than in the previous case. Here the operation should consist of opening the tumor, laying out the cyst-wall, and reducing it within the cranial cavity.

[3] *Vide* also Eigenbrodt, "Ueber Kephalhydrocelen und Schädellücken nach einfachen Schädelfrakturen im Kindesalter," *Beiträge zur klin. Chirurgie*, xi. 401.

common in rhachitic children than in others. In adults it occurs rather as a hydrops ex vacuo, resulting after atrophy of the brain. Of this kind a remarkable case has been reported by Heller.

Pachymeningitis interna may also produce a subdural exudate of this kind. In adult cases distention of cranial bones is not permitted. This occurs for the most part in rhachitic children. Hydrocephalus meningeus is of interest to the surgeon only when there is expansion of the cranial cavity. Even in these cases it is difficult to distinguish from hydrops ventriculorum. When recognized it is amenable to treatment by repeated puncture, which must be done with the most rigid precautions, and which offers better prospect of subsequent relief than do cases of the ventricular variety. An encapsulated collection of cerebro-spinal fluid is also known as hygroma of the dura. These col-

Fig. 435.



Hydrocephalus internus; dilated ventricles (U. S. A. Museum, No. 8233).

lections lie encapsulated by abnormally-formed membrane or exudate between the dura and the pia, and may even lead to expansion of the overlying skull. They are due to chronic inflammation of the dura, such as is spoken of under the head of Pachymeningitis.

In hydrocephalus ventriculorum of mild degree we find distention of the ventricles by cerebro-spinal fluid as the result of meningitis, encephalitis, tubercular disease, brain-atrophy, etc. Nevertheless, the

term "hydrocephalus internus" is usually given to a chronic distention of the ventricles with a corresponding reduction in the amount of brain-substance, or at least expansion of the skull, to accommodate the increasing fluid. The condition is practically a chronic one, and for the most part of congenital origin. The fluid collects mainly in the lateral ventricles, although the third and fourth are sometimes distended. The amount of fluid thus collected may be relatively enormous, as much even as 4000 c. c.: in one case Cruikshank found 27 ounces. Compression of the brain causes, of course, atrophy of the same, with arrest of its development, so that as a consequence there is relative reduction of its volume, and sometimes almost total disappearance of the hemispheres, which are changed into great sacs, upon whose upper and inner aspect the remaining brain-substance is spread out as a layer. The fissures and sulci are completely lost; the small ganglia are distorted, the trigeminal lengthened out, the corpora quadrigemina much distended, the gray and white substance scarcely to be differentiated, and numerous other structural alterations are noted. That there is absolute defect of the brain is ascertained by the fact that after evacuating the fluid it is found to weigh much less than normal brains of the same age. So far as the cranium is concerned, the bones of the vertex separate, so that instead of sutures we have a tightly-stretched membrane. The bones

FIG. 436.

Condition of cranial bones in hydrocephalus (Wood Museum).

themselves are flattened, and there is disappearance at many points of the osseous tissue between the pericranium and the dura. Alterations are not so marked at the base, the principal deformity being that the roofs of the orbits are pushed forward and downward. For the most

part the skull expands symmetrically; still, this is not always the case, since one ventricle may be more distended than the other.

The appearance of hydrocephalic heads is nearly always distinctive. If patients live long enough and the gradual increase of fluid be checked, the bones may finally ossify, ossification proceeding either radially or else from new centres. If the fluid steadily increase, there may be spontaneous rupture from the ventricles into the subdural space, with resulting hydrocephalus meningeus. Most of the patients with congenital hydrocephalus show also other developmental defects, such as club-foot, hare-lip, etc. If the condition be well developed during intra-uterine life, the size of the skull is considerably augmented at birth, and may constitute a very serious obstacle to parturition. Such children born without skilled help frequently die during delivery, and the mothers are seldom delivered without instrumental assistance. The so-called acquired cases are, in effect, for the most part, congenital, the condition not being sufficiently marked at birth to attract attention.

Expansion of the skull happens sometimes rapidly, sometimes slowly, and is more prominent at the fontanelles and along the sutures, where fluctuating irregularities may develop. The more the circumference of the vertex increases, the greater the disproportion between the enlarged

FIG. 437.

Hydrocephalus (Wood Museum).

skull and the small face, and the more typical the appearance of the child. When this expansion has attained a high degree the fluctuating tumors before alluded to may become translucent, while upon the scalp,

which is sparsely covered with hair, one may see enlarged veins, because of the changes at the base of the skull and pressure upon the roof of the orbits, while the eyes have a peculiar appearance, and are pressed not merely forward, but downward, so that they are nearly covered by the lower lids, because the upper lids are somewhat retracted. Because also of the peculiar position of the roof of the orbit the superciliary arches appear to be commonly raised. These patients perspire freely about the head, which often feels warmer than normal. Upon auscultation, in the region of the enlarged fontanelles there is usually audible a systolic murmur.

Most of these children present in every respect a picture of impaired development. They suffer from disturbed digestion and from constipation. Emaciation and flabby muscles are a consequence, with curvature of many of their long bones. The special senses are seldom perfectly developed. Hearing is the sense least often affected; taste and smell

FIG. 438.

Hydrocephalus (Bruns).

early disappear. Strabismus and nystagmus are frequent; the pupils are usually dilated. Willis found in one case that he could cause dilatation of either pupil by having the child lie on that side of the head. Ventricular hydrocephalus developing after the first year of life is ordinarily regarded as acquired. Under these conditions it usually develops rapidly, although not always. In rapid cases there is accompanying headache with disturbance of consciousness, cramps, and other manifold symptoms. These children desire to be always carried, wish to rest the head, complain of some degree of headache, show constant but mild pyrexia, cry in their sleep, and gradually emaciate. They have poor

control of the sphincters. After this condition has been present for a variable length of time there is noticed a gradual expansion of the skull with separation of sutures. The more distinct the condition, the more evident the signs of central paralysis. To the cases above alluded to must be added those also which follow respiratory diseases, particularly whooping cough, in rhachitic children.

The tendency of these children is to die during the first year or two of life. Recovery may follow, but is rare, and usually the most that can be hoped for is that the lesions shall remain stationary. Fatal results are usually due to increase of transudate, with resulting convulsions and final coma. Death may be produced by intercurrent disease or by such accidents as perforation and bursting of the skull with evacuation of fluid. In other cases spontaneous evacuation into the nasal cavities has been observed. Rokitansky has reported perforation of the bones of the scalp with formation of external watery tumors. In a case reported by Bacon the fluid escaped beneath the scalp into the tissue of the face, and finally burst into the nose. There are but very few cases on record of complete spontaneous recovery of well-marked disease of this kind. One of the most instructive of these is that reported by Greatwood (1858), which concerned a fifteen-months-old child born with a large head, which gradually became helpless, and one day fell, striking the

Fig. 439.

Hydrocephalic monster (Bruns).

head upon a nail, which latter was immediately extracted. When the wound produced by the nail was probed a great stream of fluid escaped, and the opening leaked freely for four days, and then closed. The child recovered the use of his limbs, and at the age of four and a half years appeared perfectly healthy. A few other similar cases are on record. In yet other cases there seems to be spontaneous resorption of fluid with

resumption of brain-function. From hydrocephalus a mild degree of recovery is by no means rare. This is most likely in rhachitic children, in whom treatment for the rickets seems to be all that is required.

It is well usually to separate the apparently congenital from the apparently acquired cases. In the former normal brain-development is more interfered with, while in the latter established brain-functions may retrograde. Beyond referring to the well-known embryological fact that the hemispheres are formed by two vesicles due to the infolding of membranes whose cavities are filled with fluid, a discussion of minute causes would take us too far from the surgical aspect of this disease. But this fact will explain how we may have extensive hydrocephalus combined with true microcephalus or with the normal-sized skull. Thus, Billard found in one child who died on its third day of pneumonia that both hemispheres had been substituted by bags of fluid, retaining almost the original rudimentary condition. Other explanations of the acquired cases must be gathered from family history, most of the parents being syphilitics or alcoholics. It is of interest also to know that the condition has been hereditary in certain families.

Diagnosis of hydrocephalus can only be positively made when the shape of the skull is changed to accommodate the increase of fluid within. Inasmuch as in young children the skull presents various types and shapes, one may be in doubt at the beginning of a case of hydrocephalus on this account, but when the sutures begin to separate and the fontanelles to protrude the diagnosis is not then difficult. When the condition has reached a high degree the skull fluctuates and is more or less translucent. Difficulties in diagnosis arise mainly in rhachitic cases, it being sometimes difficult to say whether the cranium is altered by rhachitis or by the fluid collection within. In this case a general examination of the patient's body will probably clear up the doubt. As between hydrocephalus meningeus and hydrocephalus ventriculorum, Hewett is sure that the pressing downward of the orbital plates and the peculiar appearance of the eyes are met with rather in the latter than in the former cases. As between acute and chronic hydrocephalus, Roger has relied on the existence of a perceptible systolic murmur which is always present in chronic cases.

In view of what has already been said, **prognosis** is not favorable. It is less so in the congenital than in the acquired form; less so, also, in the acute than in the chronic cases.

Treatment.—This may be partly medical, or in serious cases largely surgical. For the former the reader is referred to treatises on internal medicine. The operative treatment consists either of compression of the enlarged skull by bandaging or of removal of the fluid by puncture, with or without permanent drainage. The electrolytic method has also been suggested, but never practised to any extent. Compression has been successful, although rarely, and, as a rule, the results are not encouraging. From combined puncture and pressure at least a temporary subsidence of fluid collection may be expected, and there are numerous cases on record where, after one or more punctures, recovery has ensued, although whether this recovery was a relative or an absolute one may be doubted. Certain it is also that in still more numerous instances puncture has been followed by death. Beely found among those reported as

healed after puncture only eight cases which had been really relieved for more than a year. Compression may be brought about by plaster strips or starch bandages, but in all cases there is danger of pressure-sores, or even of gangrene; consequently, it must be carried out with caution.

The operation of tapping for hydrocephalus through the fontanelle is so old a procedure that it cannot be determined who first devised it. It certainly was recommended by Hippocrates, and later by Celsus. In recent times it has been particularly recommended by Zenner, Keen, Bergmann, Wernicke, and others. Zenner has also advised tapping the ventricles as a palliative measure in some cases of basal tumors. Bergmann alludes to the similarity of deposit of miliary tubercle on the pia mater and the peritoneum, which in either case is followed by great transudation, and states that the thought naturally comes to drain off the fluid in either case, and thereby unburden and free the circulation. It was this reason that led him to operate in 1888 on a case of tubercular meningitis in the stage of brain-paralysis. The patient's life was not materially prolonged, yet in every respect the benefit derived was strikingly illustrated. The establishment of permanent drainage was, perhaps, first suggested by Wernicke in 1881. Its principal advocate in this country has been Keen.[1] He was led to propose it by the results of an autopsy in a case of tubercular meningitis which he trephined for supposed abscess, where a tube, having been introduced, was found after death to reach within one-fourth inch of the distended ventricle, without having produced inflammation; while Ayres, Robson, and others have reported several cases which have justified the operation, without, however, having made it a brilliant success. Keen has also shown that from almost any point of the cerebral cortex it is not difficult to penetrate the ventricle, providing only that one is familiar with its location and conformation, and that when distended it is extremely easy to reach. He advises that when effusion is acute the fluid be rapidly drawn off, but that drainage should be provided for chronic cases, since in the latter, when distention has been great and brain-tissue is atrophied and distorted, it is better to drain slowly, in order to permit a gradual restoration to proper shape, should this be possible. Moreover, rapid emptying may be fatal, as shown by cases reported by Keen, Frank, and others. Langenbeck has suggested to tap through the roof of the orbit. When an abscess breaks into the ventricle rapid and free drainage and irrigation are the most promising methods. Drainage may be secured by rubber tubes, gauze, wicking, horsehair, or by even a cannula. There is at least a theoretical danger of puncturing some vein with the point of the aspirating needle. Consequently, it is perhaps better to pass in a blunt grooved director or Horsley's dilating director, by which this danger, at least, will be avoided. Draining of cerebro-spinal fluid is not, *per se*, a dangerous operation. This has been shown in numerous cases, both of cranial and spinal lesion. Championnière reported a case in 1888 in which no bad results followed so abundant a flow of this fluid as to wet the dressings, the pillow, and even the bed. It is wise in these operations to avoid the motor zone and the neighborhood of the Sylvian fissure, on account of the meningeal and middle cerebral arteries. We should also avoid known sense-centres, and utilize, so far as possible,

[1] *Med. News*, 1888, Dec. 1, and 1890, Sept. 21.

the so-called "latent" zones. Keen has proposed three routes as practicable:

1. Trephine halfway from the external occipital protuberance to the upper end of the fissure of Rolando and 2 cm. either side of the middle line. Puncture toward the inner end of the supraorbital ridge on the same side. The normal ventricle will be tapped at some point in its posterior horn. This method has the advantage of better drainage.

2. Trephine at one-third of the distance from the glabella to the upper end of the fissure of Rolando and 2 cm. either side of the middle line. By puncture at this point, which will traverse the first frontal convolution, we open the anterior commissure of the ventricle.

3. Trephine $1\frac{1}{4}$ inches behind the meatus and the same distance above Reid's base-line. Puncture toward a point $2\frac{1}{2}$ inches directly above the opposite meatus. This will enter the lateral ventricle, and by this route we have the advantage that we may either drain the ventricle or expose an abscess in the temporo-sphenoidal lobe.

While these three routes are clearly indicated, one is by no means necessarily confined to them, providing only that he proceed with caution. In an admirable summary of the operative treatment of hydrocephalus Frank[1] offers the following conclusions:

Trephining and tapping of lateral ventricles is performed—

1. For distention from acute, simple, or tubercular meningitis;
2. For effusion of blood, either from trauma or disease;
3. For collections of pus;
4. For effusion into the ventricles from brain-tumors;
5. For chronic hydrocephalus with moderate distention and without enlargement of the head; and,
6. In cases of hydrocephalus, with great enlargement of the head, which offer no hope.

One of the best articles upon the subject is by Boltze,[2] who gives some of the unfavorable as well as the favorable results of operation. For instance, he quotes Henoch, who has operated in five cases, in one of them making six different punctures, and in another having used iodoform solution after tapping without having seen the slightest benefit. He also quotes Huguenin as saying: "There is, up to to-day, no case known in which, before death, hydrocephalus had been positively diagnosed, in which puncture had been known to have positively succeeded or in which signs of real benefit have been discovered at autopsy." All authorities agree in this, that in this condition there is an increased exudate of fluid as the result of the ependymitis and the inflammatory irritation of the choroid plexus. How freely fluid may escape when drainage is carried out under some of these circumstances is shown not only by the observation noted above, but by a case of Tillaux, from which there was at least one-fourth of a litre of cerebro-spinal fluid daily evacuated through the nose. The reader is referred also to the subject of Fractures of the Base of the Skull for statements as to the amount of fluid drained off through the ear in some of these cases.

Boltze is inclined to speak hopefully of Quincke's suggestion[3] to

[1] *Annals of Surgery*, April, 1894, p. 424.
[2] *Ein Beitrag zur Operativen Behandlung des Hydrocephalus Chronicus*, Halle, 1893.
[3] *Berlin. klin. Woch.*, 1891.

make punctures not in the skull, but between the third and fourth lumbar vertebræ, making them between the spinal processes in children, and in adults to one side of the lower border of the transverse processes. This method of course rests for its justification on the communication between the subarachnoid space of the brain and the spinal canal. At this point in the spine no injury of the cord is possible, the worst that can happen being injury to some nerve in the cauda equina. He uses a pointed, hollow needle, with which he makes a tear in the dura at the point of puncture. The results of this method, however, are by no means brilliant: 3 out of 6 cases of chronic hydrocephalus died; 1 disappeared; in the fifth puncture was repeated six times with slight improvement; and the sixth was discharged recovered, but with the diagnosis of tubercular meningitis. Boltze concludes that puncture of the skull or of the spine is not to be recommended except in cases of severe pressure-symptoms from recent meningitis or in the later stages of non-tubercular meningitis; in hydrocephalus of patients with inherited syphilis; in chronic meningitis with considerable expansion of the head, where it must be frequently repeated; and in cases where there is loss of certain functions, such as vision, etc. As against these indications there are no contraindications when the operation is properly done.

For the ordinary purposes of tapping the ventricles a small trephine opening is made, and then the needle or a small trocar and cannula are directed toward the proper point and introduced. Before withdrawing the instruments horsehairs may be inserted or a small drainage-tube passed in. This is the easier if Horsley's dilating director be used. Operation must be considered as experimental in every case, since the exact internal condition is unknown. The most rigid aseptic precautions must be observed, and it may take some days to get a patient's head into a condition to permit a really aseptic operation.[1] If thought best for any reason, the ventricle after tapping may be irrigated with the warm sterilized boric solution, or, if too much fluid has been withdrawn at once and convulsions ensue, a little of this may be introduced through the opening and the ventricle partially filled again. Not infrequently we have, as a result of tapping, signs of cerebral irritation, such as irritability, crying, vomiting, cramps, pyrexia, etc. Fluid sometimes quickly reaccumulates, sometimes slowly, sometimes not at all. Inasmuch as frequently-repeated puncture seems to be not merely ineffectual in certain cases, but hazardous, I think one is justified in holding that if marked improvement do not occur after two or three punctures, it would be better to discontinue the procedure or establish permanent drainage. A few surgeons have had, in time past, the hardihood to inject iodine after withdrawal of some of the intracranial fluid In two cases reported by Tournesco it would appear that recovery ensued, while others have done it with more less impunity. I know of no records to show just how often it has been fatal. So long as improvement follow puncture it may be repeated indefinitely, although it seems to do more harm in the acquired cases, because one must perforate a

[1] I have recently seen an absolutely aseptic course followed in a case under my care, the child dying, after a week, of marasmus. All efforts to make cultures failed, and there were no signs of any cerebral complications.

thicker layer of cerebral tissue in order to empty the ventricles. Starr[1] takes the position—and, I think, wisely—that in cases of the general classes alluded to above trephining may be recommended, since if the disease be primary it may be cured, and if it be secondary the operation will not necessarily hasten the fatal termination. Such accidents as rupture of the lateral ventricle or rupture of abscesses or vessels into it may happen in any of these cases, and constitute some of the risks which must be assumed on the patient's side. While in many cases trephining and tapping must be regarded as possibly merely palliative measures, nevertheless, they are not to be put away solely because of prejudice or fear.

Epilepsy and the Psychoses.

Operative attack for relief of epilepsy is an operation which antedates the accurate history of medicine. It seems to have been practised at first purely empirically; then, when surgery became a science, to have been done with more plausible reason, after having fallen into discredit for centuries; and then, during the past ten or fifteen years, to have been revived upon its merits and upon the recognition of more or less accurate indications.[2]

Operation for epilepsy appears to rest upon two fundamental facts, the first being that it has been long noticed by many competent observers that after serious operation, either intended for relief of epilepsy or for other purposes, or even accident, the epileptic attacks have entirely ceased or have become relatively infrequent: in other words, that marked improvement in the epileptic condition has resulted. The second fact is the scientific distinction, which Hughlings Jackson was the first to point out, between epileptic attacks of a generalized character, or the so-called "idiopathic" epilepsy, whose origin is perhaps still unknown, and those which begin with a definite aura, and in which the muscular spasm follows a more or less definite order or programme, successive groups of muscles being affected according to, apparently, a fixed law for that particular case. During some of these attacks consciousness is not completely lost; in fact, seldom so, unless the attack culminate in a general convulsion. This form of epileptic seizure is that now generally known as "Jacksonian" epilepsy, and is that in which operation is most often of real service. So far as we can grossly perceive the cause in this class of cases, it consists of irritation in the excitable portions of the cortex, which irritation appears to radiate from some particular point, and to grow less severe as it reaches other centres in the neighbor-

[1] *Brain Surgery*, p. 263.

[2] Broca, in his *Memoir*, has shown that attempts to cure epilepsy by boring or chiselling away portions of the skull as a cure for the *morbus sacer* dated back into the prehistoric era, it having been held then that this was the operation which sanctified the patient operated on. As the operation became more limited in its application, especially from the time of Desault to that of Dieffenbach, its employment in epilepsy became less and less frequent, until during the last thirty or forty years, for the most part, only those cases were trephined which presented some external marking. Seidl, who published his memoir, *Ueber Antiseptische Chirugie*, in 1886, could find only 29 cases which had been trephined for epilepsy since the introduction of antiseptics. *Vide*, also, Rolland, *De l'Epilepsie jacksonienne*, pp. 21 et seq. (Paris, 1888), and Fränkel, "Zur Frage der Schädeloperationen bei Epilepsie," *Billroth's Festschrift. Beiträge zur Chirurgie*, 1892, p. 103.

hood.[1] In the spasms of the Jacksonian type there is a certain order of progression, depending largely upon the relations of the motor centres to each other. Thus, irritation beginning in the leg-centre cannot reach the face-centre without traversing that for the arm. Accordingly, the order of progression would be leg, arm, and, lastly, face. This is so far as possible true also of the sensory centres for the special senses, any of which may be irritated, with perverted sensations in consequence; so that it may be possible to have a sensory equivalent for a Jacksonian attack which should be regarded as just as diagnostic as though the corresponding phenomena occurred in the motor centre. Attacks commencing with peculiar sounds indicate irritation in the centre for hearing or in the temporal region; those beginning with optical phenomena indicate occipital irritation; those with disturbances of smell or taste show irritation in the temporo-sphenoidal region.[2]

Discarding for present purposes all cases recorded prior to ten years ago, discarding also those in which epilepsy has subsided after operations not primarily intended for this purpose, one may say that, in spite of a large percentage of failures, the operation is no longer *sub judice*, but should be incorporated among our standard and promising measures for relief of this condition. A large majority of complete failures have been due rather to failure to do enough at the time of the operation, and, having myself operated upon numerous cases for this purpose, I have reached the conclusion that, for my own part, I have never done too much, but have sometimes not done enough. When operation is undertaken for the relief of a condition absolutely of traumatic origin, it may be sufficient to excise external scars, to remove bone freely, and to separate adhesions should these constitute the apparent cause.[3] It, however, is not enough to simply break up an adhesion which may quickly form again, and when such operations apparently fail they fail because of insufficient thoroughness. These are among the cases where I would urge the measure first proposed by Beach of Boston, and to which I have elsewhere alluded in most complimentary terms,[4] of inserting a piece of gold-foil, carefully sterilized, between the pia and the dura, which shall permanently separate the two and prevent re-formation of adhesions. I have resorted to this a number of times, and have never seen the slightest untoward consequence follow.

[1] Certain analogies have also been drawn between artificial production of epilepsy in animals and the results of operation in men. For instance, Westphal found that by repeated blows upon the heads of guinea-pigs these animals could be put into such a condition that there was found in certain areas over the skull what were characterized as "epileptogenic zones," whose slightest irritation was enough to produce epilepsy. It was further found that after excision of these irritable areas the animals lost their susceptibility to the disease.

[2] See Starr, *Brain Surgery*, p. 22.

[3] According to Gerster and Sachs (*Am. Journ. Med. Sci.*, Nov., 1892, and *N. Y. Med. Journ.*, Feb. 20, 1892), the excision of centres in children is less serious than in adults, since there is in them greater possibility of substitution of function. Sachs lays great stress upon the fact that traumatism calls for immediate surgical interference; believes that it is much better to operate when one is in doubt and has to deal with a real injury of the skull than to leave a depression which will afterward be a source of irritation. He has shown that in 44 per cent. of infantile cerebral palsies epilepsy has developed. As the most of these were hemiplegic, and most of them were due to circumscribed lesions, one may draw very positive inferences.

[4] *Med. News*, Dec. 10, 1892.

In other cases of operation for non-traumatic lesions—as, for instance, the presence of enlarged Pacchionian bodies, or clots,[1] or neoplasms, or degenerations of any kind pressing upon or lying in the cortex—men have usually hesitated to remove a sufficient area of involved brain-substance, fearing lest the paralysis which may follow should be regarded as a more serious effect than the epilepsy. Of such mistaken conservatism there is this to be said: that the very benefit expected is not likely to follow unless such centres be absolutely removed; that it is far better to remove too much than too little; and that in scarcely any instance recorded has the paralysis which followed remained permanent; but that by some beautiful provision of nature—call it substitution or what we may—there is such rearrangement and restoration of function as to permit almost complete recovery of function in the parts involved.[2]

For the reason that operators have been so unobservant in this particular, and because the work of one man can scarcely be compared with that of any other, I have preferred to make no reference to statistics of these operations, which are sure to be most misleading.[3] If one may judge by the results obtained by those who are most thorough in their work, operation is always justifiable, if not invariably successful, in the class of cases already specified. On the other hand, if one goes by the work of those who are less thorough, he will get information from this source alone which is likely to be most discouraging. In general, then, it may be said that in the cases which are suitable for operation the result to be obtained will depend almost entirely upon the personal equation of the operator—*i. e.* his thoroughness.

The most common causes of traumatic epilepsy are the results of old depressed fractures, whether compound or not, and the presence of clots or their relics, usually in the form of cystic degenerations of the same.[4] The first operation in America undertaken strictly according to

[1] How thick the bone may be in some of these cases the instance reported by Mills and Keen in the *Journal of the Am. Med. Ass'n.*, Dec., 1891, in which the writer manipulated the trephine, will show. The button of bone removed was seven-sixteenths of an inch thick.

[2] The matter of complete excision of limited areas of the cortex has become associated with various considerations. Munk and Heidenhain succeeded in checking convulsions of one side by rapidly extirpating the whole motor area of the other; and Novi in Luciani's laboratory corroborated these experiences by making a rapid incision with the knife into both sigmoid gyri during convulsions in a dog, by which every movement of the extremities was stopped, there remaining only rhythmical motions of the muscles of the face and lower jaw. Even these would disappear if the incisions were prolonged outward and downward to the areas which controlled the muscles of those parts.

[3] In scarcely any field of surgery have figures proven so fallacious and valueless as in the study of the results of operative treatment of epilepsy. It would almost seem as if the more cases we collect the less certain we become. MacDougalls collected in the *Journal of Mental and Nervous Disease* for 1883 (p. 417) 296 cases trephined for epilepsy, stating that not less than 179 recovered, while 50 died. The extraordinarily favorable showing in this collection is apparently due to a very hasty and ill-considered digest.

[4] According to Navratil (*Beiträge zur Hirn Chir.*), it is a significant fact that injuries to the head which leave only small scars, and which at the moment of injury have produced no real brain-symptoms, are not followed by epilepsy, the only exceptions to this rule being hystero-epileptic or neurotic individuals, who are predisposed by virtue of their previous condition.

Le Dentu (*La Presse médicale*, June 9, 1894) summarizes the known causes of traumatic epilepsy as follows:

1. Fragments of bone resulting from fracture;
2. Bony outgrowths due to traumatism, although when slow compression occurs the brain usually accommodates itself to new conditions;

the teachings of cerebral localization was done by the writer in 1885.[1] This was a case of cystic degeneration of a clot which permitted of easy localization, and was one which now would provoke no comment at all. Recovery quickly ensued with only partial alleviation, since the cyst had been present so long as to produce almost complete atrophy of the underlying speech-centre. Other more or less common causes of traumatic origin are adhesions between the membranes and external cicatrices, which become bound to the bone, from which there proceeds some faint but positive reflex irritation. Such always demand complete excision. Lesions of non-traumatic origin may be due to spontaneous hemorrhage, to congenital defect, to neoplasms of the scalp, cranium, membranes, or the brain itself, to thickening and enlargement of the Pacchionian bodies, and to certain other lesions scarcely to be catalogued or grouped.

Starr[2] has had the thickened pia met with in a case of this epileptic character microscopically examined, sections revealing a sclerosis in patches of the neuroglia tissue which might form a sufficient focus of irritation to cause a local spasm. When the pia forms the inner wall of a cyst—as it may in cases of old subdural hemorrhage—it becomes much thickened and opaque. In certain long-standing cases there is formation of new connective tissue between the pia and the cortex, which is succeeded by more or less secondary degeneration of the cortex, which has been followed even into the spinal cord. It often happens that the cortex is changed in its appearance from the later effects of fractures or of meningitis. It may be stained with hæmatine at the site of previous hemorrhages; it may be compressed and indented or sclerosed; or, on the other hand, it may be softened or actually lost and disintegrated. Cysts are for the most part relics of previous hemorrhage, the fluid being commonly clear serum. When they are merely emptied they refill. For their complete disposal it may not be necessary to absolutely excise the entire cyst, but the larger portion of the wall at least should be dissected away, the more thoroughly the better. Cysts are met with in connection with glioma also, and it has been suggested that epilepsy in which cysts were found were really cases of beginning glioma.

From all this it is evident that in at least a certain proportion of cases of epilepsy and kindred disorder, particularly those presenting the Jacksonian type, there is a definite and usually perceptible lesion or pathological change—that is, an organic basis for the disease; and it is reasonable to infer that when the pathological changes have not gone too far there is an opportunity for extirpation of the diseased area to produce the desired effect. It is particularly in those cases where the area involved is not vague, but distinctive of easily perceptible changes, that it has been suggested by Horsley and others to resort to faradic excitation for the purpose of localizing and reproducing, so far as possible, the spasmodic features of the disease, the faradic current being applied by

3. Meningeal cicatrices, which are at first soft, but later become hard and adherent.
4. Incipient chronic meningitis, ending in sclerosis of the membranes.
5. Cysts resulting from intracranial hemorrhage.
6. Arterio-venous aneurysm, a case of this kind having been described by Warnots of Brussels.

[1] *Trans. Congress of Am. Phys. and Surg.*, vol. i. p. 321; and *N. Y. Med. Journ.*, Nov. 3, 1888, et seq.

[2] *Brain Surgery*, p. 71.

two small poles from 50 to 100 millimetres apart in an insulated handle, in order to determine the exact spot at which irritation will produce the muscle-spasm which may be seen in the course of an epileptic seizure in the same patient. (For this purpose Keen has devised an admirable electrode.) After this spot has been once definitely located it should be completely and widely excised. To be sure, there is a theoretical objection to this—that such excision is necessarily followed by the formation of a scar, and that we have substitution of a sclerosed area for more or less normal cortex. This, unfortunately, is a somewhat well-founded objection, and will doubtless explain recurrence of seizures in cases temporarily benefited by some of these operations. That it is not invariably the case, however, clinical experience amply demonstrates, and the objection is not so forcible as to make us abstain because of the possibility of its occurrence. There is every reason to think that in the human brain at least there is no complete reproduction of the lost parts, and that in the cicatricial tissue which results from such excision the true nerve-elements are not reproduced according to the original arrangement. Nevertheless, there is assumption of function on the part of the adjacent brain-tissue, and the paralyses caused by excision of diseased areas when this is made for relief of epilepsy are seldom more than temporary.[1]

With reference not merely to the final outcome, but to the post-operative treatment of these cases, the writer desires to insist upon the continuance of suitable treatment for a considerable, perhaps a great, length of time after operating. This is particularly necessary in cases already of long standing before they are seen by the surgeon. More and more my conviction grows that there persists in these cases the so-called epileptic habit, even though the primary irritation be relieved, and that for the relief of this habit continuous although gentle medicinal treatment is necessary. This would probably consist of the bromides, possibly in connection with borax, as advised in the standard works on therapeutics; and, inasmuch as many cases of idiopathic epilepsy are probably but expressions of an auto-infection, it would be well not to lose sight of this fact in the surgical cases, but to improve the excretions in every possible way, to regulate the diet (absolute rest in bed and prolonged milk diet being the best), and to proceed with as much caution and intelligence in these matters as though the case had never been operated, and as though the success depended entirely upon precaution here. The more of these troubles with which I have to deal the more firm this conviction becomes.[2]

Finally, there must be inserted here a plea to the effect that the earlier the operation be done the greater the prospect of success.[3] I

[1] Vide also Kocher, *Deutsche Zeitschft. für Chirurgie*, Bd. xxxvi. pp. 1 et seq.

[2] Herter (*N. Y. Med. Journ.*, Sept. 3, 1892) has shown that excess of intestinal putrefaction is a frequent factor in cases of *grand mal*, which of itself shows how important is the regulation of diet and perhaps the administration of suitable intestinal antiseptics. This entero-sepsis, however, is apparently most operative in these discharging lesions, and is probably connected in some way with the predisposition to excesses in manifestation of nervous force.

[3] Bergmann has but little to say in favor of operations where surgeons simply operate in order to see whether they may help their patient, and is personally opposed to what he calls such "irregular" proceedings. Nevertheless, he acknowledges it proper to make use of, and apply at the bedside, the results of experiments upon animals.

have had a number of brain cases whose history shows that at the time of reception of injury the symptoms were so serious and severe as to lead the medical attendants to consider the case so hopeless that practically nothing was done. In every possible way this apathetic course should be condemned, and the strenuous advice is given that the most desperate cases be attended at once and with the same attention to detail as though the outlook were hopeful. Disappointment and partial or complete failure in late operations will be too often the necessary outcome of any other course. Also I wish to urgently advise that there is almost as good reason for early operation in these instances as when we have to deal with malignant disease, since, though the pathological alterations are less rapid, they are scarcely less certain, and the general professional public need to have it profoundly impressed upon them that prognosis is very much more favorable after early operation than when it be delayed so long as is often the case.

There has also been described an aphasic form of epilepsy, due to irritation, followed by arrest of function, in the motor speech-area, which in right-handed persons is in the left third frontal convolution. Lastly, there are psychopathic equivalents of epileptic disturbance, which are manifested by temporary mental alienation or by maniacal excitement or by a certain amount of dementia, which probably indicate disturbance of function in the frontal region, although this cannot be positively stated as yet.[1]

Whenever any of these psychic disturbances are evidently of traumatic origin, or whenever any indication, either from surface-markings or from the history of the case, can be obtained to account for mental phenomena of this character, or, finally, whenever by application of

[1] Mental disturbances after head-injuries have long been known. Fallopius (*Observat. Anat.*, Venet., 1561, cap. 45) said: "Vidi multos in quibus egressus est cerebrum et aliquot remasere stupidi," while Borelli, Fabricius Hildanus, and others, centuries ago, recorded their experiences. These cases have also a peculiar medico-legal interest in many instances. Mitchell estimated that 2 per cent. of all the insane in Scotland were so because of injuries to the head, and these always figure in the list of causes. Prognosis is always better when the first sign of mental disturbance follows soon after the injury. When these cases die, as many of them do, from dementia or anæmia, there is usually found more or less cortical or general brain-atrophy, with dilatation of, and collection in, the ventricle, thickening and opacity of the pia, and pachymeningitis.

The suggestion to open the skull in insanity is not new, although of recent execution. Burckhardt (*International Journ. of Surg.*, Oct., 1891) has detailed six cases of insanity, with marked hallucination, subjected to operation. His results were encouraging or satisfactory. In insanity due to intracranial gross lesions the indications always are to operate (Laurient, *Journ. de Méd.*, May 20, 1891).

A case of operation *for acute traumatic mania* has been reported by Patterson (*Occidental Med. Times*): A man of twenty-eight, kicked in the head by a horse a year previously; lesion in front of the right parietal eminence; suffering from acute mania. There had been constant headache from the time of accident; pain was referred to the parietal and occipital region of injured side; also to left arm and leg, with numbness of thumb and index finger of left hand. Slight depression found at site of the injury. After trephining at this point the bone was found abnormally thick and the dura an unhealthy gray in appearance; dura not opened, scalp-wound sutured. Patient was perfectly sane for the first twenty-four hours, then relapsed for a few days, but after this began to improve, and completely recovered. Sensations referred to left arm and leg entirely disappeared. Opening in the skull refilled with bone.

I have also reported several cases of operative treatment of this form of mental alienation. (*Vide Medical News*, Dec. 3 and 10, 1892.)

(See also an important paper by Garmany, *Trans. Ninth Internat. Med. Congress*, i. p. 601.)

a knowledge of the physiology of the brain and the anatomy of the sense and motor centres, the presence of a mechanical irritation in a definite area can be foretold, such a case is one which not only justifies, but usually demands, operative interference for relief from—and if possible, the eradication of—the disturbing cause. Obviously, the earlier in the case that such interference may be resorted to the better for the patient, since it has long since been shown that there may be established that which we can best call an "epileptic habit," as the result of which epileptic phenomena may continue indefinitely, even after the removal of the original exciting cause.

TREPHINING FOR CEPHALALGIA AND PAINFUL AFFECTIONS OF THE HEAD.

It has occurred to many general practitioners to meet with cases of more or less intense and localized headache, which are apparently remotely due to injury, in which scars or surface markings of any kind are absolutely lacking, and in which explanations fail as completely as do all forms of drug-treatment. Undoubtedly some of these cases are to be explained by meningeal thickenings or by lesions involving the dura which produce no external markings. In a certain number of cases of this character, where other measures have failed, relief, partial or absolute, has followed an operation done on purely empirical grounds.[1] Sometimes a physical basis for the pain is discovered, at other times nothing abnormal can be detected, but relief has come in spite of the vagueness of the case. It would seem now to be justifiable surgery in any case of localized cephalalgia, whether constant or not, so long as the pain is well located, and which has resisted internal medication suitably directed, to subject it to an exploratory trephining, since this can be done with an absolute minimum of danger and very great prospect of relief. Precisely how the good result is produced we cannot always say. Sometimes it is due to relief of tension or to the production of a relief-opening, as it has been aptly termed by Weir. In other instances it is apparently plain that as the result of the operation nutritional changes and alterations in the circulation have been permitted, whose outcome was relief.

[1] It was Bauer who signalized the analogy between iridectomy in certain cases of glaucoma and trephine or other relief openings in the skull for relief of certain lesions of the brain beneath. (See also White's paper on the "Curative Effect of Operations *per se*.")

An illustrative case of trephining the frontal for chronic headache is that reported by Hawkes (*Med. Rec.*, Aug. 25, 1894, p. 237): Male patient, æt. twenty-eight, complaining of headache of twenty years' duration which followed a cut on the right side of the forehead and the result of a fall at the age of eight. Soon after this injury he began to suffer from headaches, complained of particularly in this region, which increased in severity until they became almost unbearable. At last they assumed a paroxysmal type and were preceded by a premonition of an aura. Eye-strain and other common causes of headache were eliminated by careful examination. Finally was trephined, a slight depression being found in the bone; no particular lesion found in or about the bone. Dura appeared so healthy that it was not opened. Wound healed properly; patient completely relieved.

Two similar cases have been reported—one by Horsley and one by Weir—referred to in Starr's *Brain Surgery*, p. 272.

Intracranial Tumors.

Until within a few years tumors within the cranium were regarded as having great pathological interest, as affording opportunity for brilliant diagnosis, but as so essentially hopeless that but little attention had been given to the feature of their therapeutics or operative relief. Interest in the subject was enhanced by discoveries in the field of cerebral localization, and finally, as the result of greater exactness in diagnosis and greater experience in experimental surgery upon the lower animals, it was discovered that a certain small proportion of them were amenable to surgical treatment with a reasonable degree of security and safety. The brain is no longer a *terra incognita*, nor is it now a sanctum which none may enter nor explore. There is, moreover, good reason to believe that with greater accuracy of anatomical and physiological knowledge, which shall permit more accurate localization of lesions, we may go further with success than we have yet dared to go. As the writer remarked in one of the early public discussions on this subject in this country,[1] "Not much less astonishing than the discovery of the planet Neptune at the spot determined by the suspicions of Le Verrier was the first discovery of a cerebral lesion at exactly the point indicated by careful study of somatic disturbances. Both were wonderful examples of inductive reasoning." This is not the place in which to discuss the general pathology of tumors nor the physiology of the brain. There are large monographs to which the interested reader must be referred for particulars in these directions. We can only attempt a brief review of the salient points which may guide the surgeon in diagnosis and in operation. Most of these cases are referred to the surgeon by the specialist in nervous diseases or the general practitioner with a diagnosis of probable lesion, which, however, should be confirmed, if possible, before operating, otherwise he should decline the responsibility unless the operation be represented and accepted as, at least at first, a pure exploration.

Frequency and Variety.—Tumors of the brain and meninges occur with about equal frequency during childhood and adult life. The cases collected by Starr[2] and by various other authors show that in order of frequency they stand about as follows; Tubercular gumma; glioma; sarcoma; cysts; carcinoma; syphilitic gumma; with a small proportion of fibroma, etc.

In all probability, gummata, either of tubercular or syphilitic nature, are much more frequent than all the other varieties put together. Yet but relatively few of the latter find a place in literature. This is particularly true of tumors in adults. The explanation of this is probably the influence of treatment in dispersing syphilitic new formations, while over others drugs have little or no influence. Gliomata and other forms of sarcomata appear about equally frequent in childhood, while in adults the latter predominate, as do also the carcinomata. Cystic tumors are either of independent origin or arise from degeneration of other forms. The parasitic cysts are very rare in this country—more frequent on the

[1] "Surgery of the Brain, based on the Principles of Cerebral Localization," *N. Y. Med. Journ.*, Nov. 3, 1888.

[2] *Brain Surgery*, p. 202.

continent of Europe, where Küchenmeister has collected eighty-eight cases. Cysts which are merely the result of hemorrhage are scarcely to be reckoned among tumors proper, yet I have thought best to include them here, since they produce some of the symptoms of tumor, especially when located in the motor area. Some forms of tumor are more likely to be multiple than others. This is particularly true of tubercular gummata, which are so frequently multiple that symptoms pointing to more than one tumor would make probable a diagnosis of tuberculosis.

(In this connection the question may be raised whether a diagnosis of tuberculosis should be regarded as contraindicating operation. Bergmann thinks that it should, while Horsley takes the opposite view, save in cases of distinctly multiple lesion. Several surgeons have certainly successfully removed a number of tubercular tumors without relapse.)

Gumma being the form of tumor most likely to develop in adults, when a diagnosis is at all uncertain the test of specific treatment should be always applied. Yet, if we follow Horsley's advice, the duration of medicinal treatment should not exceed six weeks, providing no marked improvement be noted.[1] Starr would extend this time to three months.

As between the various cancerous tumors of the brain it is virtually impossible to differentiate, unless the presence of tumors elsewhere in the body may give some evidence of value. Glioma is the most vascular of any of these tumors; consequently, it has more or less of the erectile character and may vary in size within certain limits. If, then, there be marked variations of intracranial pressure, we may have good reason for diagnosing glioma. These cases may also be accompanied by hemorrhages in or near the tumor, which will furnish apoplectic symptoms. Nevertheless, these are not to be expected in every case: they are simply indicative when they occur.

Obviously, the tumor most suitable for operation is that which is firm, encapsulated, and non-vascular. Many of the sarcomata comply with these conditions; the true gliomata, never. A case in which there are no vascular symptoms is therefore more promising, while one in which they are distinctly present cannot be regarded as favorable. The tubercular tumors are seldom encapsulated, and usually there is a zone of infiltration about the principal mass which constitutes a dangerous area, since to remove it is often to create too much havoc, and to leave it is to invite speedy recurrence or reinfection.

Of the various cystic tumors of the brain, not the least interesting are those of the arachnoid. These are often found in the insane, and are generally associated with some debilitated condition of the blood or the nervous system, as has been shown by Sutherland.[2] After exposure by

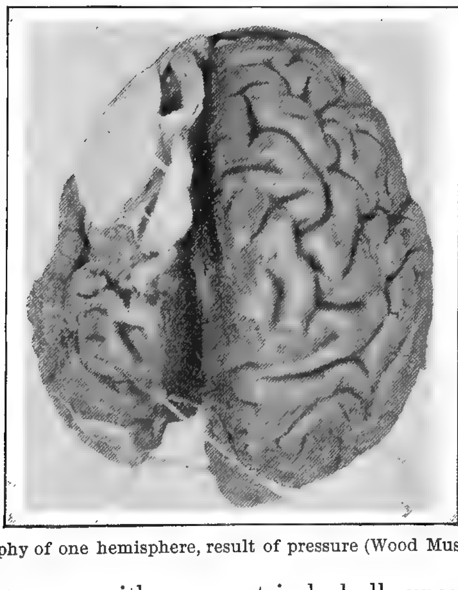
[1] That syphilitic gumma may give rise to alarming symptoms, and that it may be successfully dealt with, and apparently permanently cured, by operation, is illustrated in the case of a woman of thirty-nine, a patient of my colleague, Dr. Parmenter, who operated for a lesion, evidently of considerable magnitude, in 1890, excising an involved area exceeding a silver dollar in size; also an area of underlying pia and cortex some two inches in diameter, leaving a depression three-fourths of an inch deep. *In toto*, the amount of cerebral substance removed equalled one and a half tablespoonfuls, corresponding in location to the inferior parietal convolution, angular gyrus, and superior parietal convolution. She made a complete recovery, and has remained well up to date of present writing. This case, it will be seen, was operated on quite in accordance with views enunciated by Horsley, and shows the advantage of surgical measures over drug treatment.

[2] *West Riding Lunatic Reports*, vol. i.

removal of bone they appear as reddish, pulpy, fluctuating swellings, beneath which the outline of the convolutions is not to be made out. They adhere to the visceral arachnoid, especially along the fissures. Wilkes has stated[1] that they are found usually on only one side of the head, but Sutherland has reported 10 cases, 5 of which had cysts on both sides. These cysts may be so extensive as to practically envelop the hemispheres, but they usually take the form of a small tumor or may consist of two large flat walls of organized lymph. They may be so soft as not to be removed without tearing, or so strong as to bear rough handling. Even when they lie apparently isolated their substance may contain minute vessels. They most frequently follow blows and injuries to the head. All conditions which contribute toward cerebral congestion are conspiring causes. In the course of their formation they may appear as thin layers of blood, so soft as to be easily rubbed away by the finger, or as thick leathery clots. So far as their effect upon intelligence is concerned, they are frequently found in the insane, and seem to cause organic dementia or various degrees of idiocy and imbecility. When blood is so effused into the arachnoid as to lead to this cyst-formation the hemorrhage is usually slow and gradual, and, the surrounding parts becoming accustomed to the presence of blood, no acute symptoms follow, at least not at first.

There is no one symptom present during life which, taken by itself, is diagnostic of an arachnoid cyst, but by a combination of symptoms we may make a tentative diagnosis, such, for instance, as organic dementia

FIG. 440.



Atrophy of one hemisphere, result of pressure (Wood Museum).

in an intemperate man with asymmetrical skull, unequal pupils, poor bodily health, impoverished blood, and with a history of injury to the head. Hewett has called attention[2] to a case of dissemination of blood

[1] *Journ. of Ment. Sci.*, April, 1865. [2] *Med. and Chir. Trans.*, vol. xxviii.

in patches over the surface of the arachnoid, the intervening parts being natural, with extravasation into the cavity of the same. The patient lived nine days, and each patch of blood was found already covered by a membrane of its own. It is now universally agreed that these cysts are formed by some change occurring in the extravasated blood, and that they are due neither to splitting up of the dura nor to organization of lymph previously poured out. The results of continuous pressure by cysts of this character are well illustrated in Fig. 440.

Dermoid cysts occur inside the cranial cavity as well as outside. They are met with both in the membranes and in the brain. They are most commonly observed in the following locations: in the neighborhood of the petrous portion of the temporal, of which variety 20 cases have been gathered by Mikulicz; in the occipital region—1 case reported by Mueller; in the frontal region and bone—2 cases by Esmarch and Cruveilhier. These were for the most part situated in the bone. Naturally, dermoids of the petrous bone are most easily explained by the embryological development of this part of the cranium. Cysts which are really entitled to be considered as dermoid have been described not infrequently as cholesteatomata, which were at one time spoken of by Virchow as "pearly tumors." They have been found in the torcular, in the tentorium, just above the auditory meatus, and at the occipito-mastoid fissure.[1]

Dermoids have also been found in the brain itself, back of the pons, in and around the medulla and cerebellum. Intracranial dermoids seem to increase very slowly and insidiously, and are very seldom productive of symptoms and signs. Only under unusual circumstances do they give rise to primary trouble, as in a case reported by Esmarch, where a dermoid of the petrous bone perforated into the tympanic cavity, and was the occasion of a purulent leptomeningitis.[2]

The principal other form of cyst met with in the brain is the hydatid

[1] A very interesting case of Ogle's is as follows: Just above the occipital spine there was found an opening, admitting an ordinary probe, which passed obliquely to the inner side of the skull. Here was found a tumor $1\frac{1}{2}$ inches long, 1 inch broad, connected with the dura, which had been pushed aside to the sinus, and which connected with the opening in the bone. In the fistulous track were found several hairs.

[2] *Serous Cysts.*—These are to be distinguished from the dermoids, which may contain more or less serous fluid. They are even more rare, except those which are distinctly of hemorrhagic origin, Heineke having been able to collect but eight distinct cases of this kind. In one such case, reported by Weiss, the cysts developed suddenly ten days after birth. In most of these cases they were of congenital origin. Five times such cysts have been found in the occipital region, once along the sagittal suture, once at the internal angle of the orbit, and once at the side of the frontal and temporal region. Of the five occipital cysts, three were located between the skin and the aponeurosis. One of these was the size of a child's head. In another one, the size of a hen's egg—removed from a woman aged twenty-five—there were found numerous openings in the bone, occluded only by fibrous tissue. Two of the eight were multilocular cysts. In Weiss's case the cyst was found to be translucent and to lie in the depression of the bone. It was first punctured, and after refilling was incised. Death occurred by meningitis. It is possible that at least some of these cases were originally small meningoceles which had been shut off during intra-uterine life. It might cause considerable difficulty to distinguish between such a cyst and a cephalocele. Still, some of them have been so flaccid that one could make out distinctly that there was no bony opening between them. In case of doubt the exploring needle should settle the question. These cases might, in some measure, resemble certain other cysts of congenital origin—*i. e.* those of branchial origin, such as have been reported by Otto, Heineke, and Soemmering of five-month fœtuses, in which peculiar double cysts filled with serum were observed along the posterior surface of the neck, extending from the cranium around to the ears and below to the level of the scapulæ.

or echinococcus cyst, which of course belongs to those of parasitic origin. Hydatid disease of any form is very rare in this country, and is usually seen among immigrants. Nevertheless, a few cases met with in the brain have been described. Mudd[1] reports a case of this kind in which the tumor, present above the right ear, could be indented on firm pressure, and which returned to its place with a sort of snap when pressure was released. There were signs of cortical irritation, evidenced by paresis of the left hand and arm, and then of the entire left side, which finally merged into complete left hemiplegia. After incision of the dura and operation a clear watery fluid escaped; a number of cysts were found and removed. The excavation in the brain left by their removal was cleaned, and the patient made a proper recovery, although there was some hernia cerebri, which was obviated by pressure. From the initial symptoms to the date of the operation was eight months.

According to Cobbold, out of 327 cases of hydatid reported in literature, 22 only were found in the brain. Up to 1883 only 19 cases of echinococcus of the brain had been reported by Steffins. Since then about 9 others have been collected, on 3 of which operation had been made, and of which 3 only 1 recovered.[2]

It is interesting to note that after removal of cysts—and this was particularly noted in Mudd's case—as after certain other operations upon the brain, there is pyrexia. The question of heat-centres is still unsettled; but these have been placed by Hughlings Jackson, Ott, and others in the neighborhood of the corpus striatum and in some place in the neighborhood of the fissure of Rolando. Both of these heat-centres were implicated in Mudd's case, and the temperature was highest when the hernia cerebri reached its greatest dimensions—*i. e.* 109.4°. With the reduction of the hernia by pressure temperature returned to the normal. In a case mentioned by Sawadouski,[3] the pyrexia could be explained post-mortem only by the existence of a hydatid cyst in the corpus striatum.

There are cases on record of spontaneous discharge of small hydatid cysts through the cranial bones, as well as through the nose and mouth. Cases of echinococcus cysts rupturing into the ventricles and thus causing death are also on record. There is nothing peculiar in the hydatids of the brain which facilitates diagnosis more than in similar cysts in any other part of the body.

Tumors arising primarily from the meninges may press upon, or later secondarily involve, the brain beneath, and will be in most cases indistinguishable from tumors of the brain proper. According to their location these give rise to localizing symptoms. In some cases there will be complaint of pain. It must not be forgotten in this connection that tumors arising from the scalp or from the bone may grow downward and press upon, or even attach themselves to, the brain, and in this way cause disturbances of a character not essentially different from those of primary intracranial origin. These, of course, permit of examination and diag-

[1] *Am. Journ. Med. Sci.*, April, 1892.

[2] One of these was operated on by Castro of Buenos Ayres (*Jahrbuch. f. Kinderheilk.*, vol. xx.); the second by Verco (*Annales del Circulo Argentino*, Oct., 1889); and the third, the successful one, by Graham and Grubbe (*Am. Med. Journ.*, July, 1890).

[3] *Centralblt. f. med. Wissenschaft*, 1888, No. 8.

nosis in a way not to be thought of in the other instance. They have already been discussed at sufficient length under the caption Infections of the Scalp and Bones of the Skull.[1] These tumors of, for the most

FIG. 441.

Tumor of dura (Wood Museum).

part, malignant growth—fibromata springing from the dura and osteomata arising usually from the diploë—are occasionally met with. That primary malignant disease of the deep and more delicate membranes is possible is shown by numerous cases on record.[2]

SITUATION OF BRAIN-TUMORS.—Information of some value can be arrived at from the study of statistics with regard to the situation of intracranial tumors. With regard to those pertaining to the brain alone, one may learn, by reference to Starr's *Brain Surgery*, that of 600 tumors of the brain in children and adults, 185 were in the cerebral axis, including in that term the basal ganglia and internal capsule, the corpora quadrigemina and crura, the pons, and the medulla ; consequently, the base of the brain. Such tumors usually give rise to numerous local symptoms, largely those of involvement of the cranial nerves. Up to the present day these tumors are regarded as inaccessible by the surgeon, and consequently not amenable to treatment. There were 141 tumors of the cerebellum, which were twice as common in children as in adults—on 16 of which operations were made, in 9 of which 16 the tumor was not found. In 2 cases it was found, but could not be removed. In 5 cases it was removed, and 3 of these died. 10 per cent. of the 600 cases were multiple tumors, which, so far as at present we can go, must be regarded as inoperable—particularly so when the diagnosis can be made, since tumors which are distinctly multiple will probably thereby show themselves to be beyond the possibility of operative relief.

[1] *Vide* Delagenière, *Archives provinc. de Chir.*, ii. p. 92.

[2] Reymond (*Bull. de la Soc. d'Anat.*, Dec., 1893) reports, *e. g.*, such a case in a man of thirty-three, giving no previous history. He became paralyzed without anæsthesia, the eyes being also affected. The psychical symptoms consisted of constant delirium of ordinary type. Autopsy disclosed a tumor in the frontal region attached to the brain and adherent to the dura. By careful dissection and examination it was made evident that the tumor arose primarily from the arachnoid, was a sarcoma, and that into it had occurred repeated small hemorrhages.

The cases which can be suitably attacked by surgeons are those involving the centrum ovale and cortex, of which character 234 were found in Starr's 600 cases. It seems as yet impossible to distinguish cortical from subcortical tumors. Of the 234 cases, 164 were near

FIG. 442.

Sarcoma of brain (U. S. A. Museum, No. 7983).

enough to have been reached by the surgeon, and among these cases 46 presented clear indications for operation, and of these latter in at least 37 the attempt would in all probability have been successful. That is, out of 600 tumors, 37 could have been undoubtedly removed—*i. e.* about 6 per cent.—which, in effect, reduces the possibilities of surgery in intracranial growths to a really discouragingly small percentage. Hale White studied 100 cases of tumor from the museum of Guy's Hospital, and found 10 which might have been safely removed. Mills and Lloyd also found 10 per cent. of cases amenable to operation. Knapp[1] estimates that 7 per cent. out of 485 cases collected by Bernhard could have been removed. Dana has had an exceptional experience, and states that of 29 cases under his observation, in 5 removal could have been made. Averaging the results of all these observers, we gather that about 7 per cent. of cases of brain-tumor are suitable for operation for radical relief.[2]

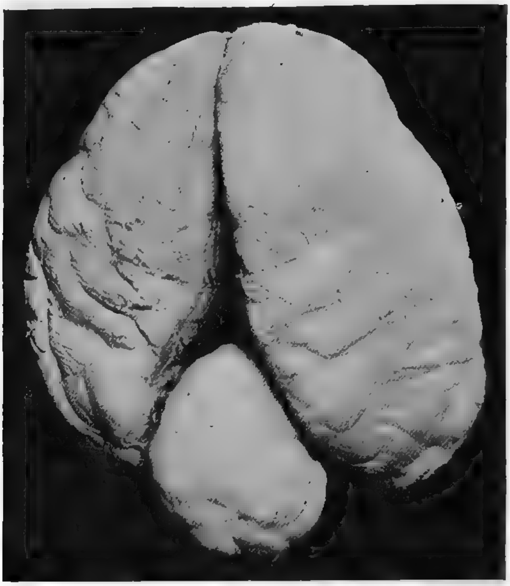
[1] *Intracranial Growths.*

[2] Seydel (*Verhandl. der Deut. Gesellschaft f. Chir.*, 1892) discovered a record of 100 brain-tumors among the records of 8488 autopsies in the Munich Pathological Institute, only 3 of which did he consider operable. Tuberculosis was the assigned character of 27 of the 100. Of 50 cases of brain-tumor discovered by Beck in examining 6177 post-mortem records in Heidelberg, 24 were excluded at once as entirely inoperable. In 4

Undoubtedly, however, there are as many more in which relief of pressure-symptoms would be afforded by what has been called by Weir and others "relief opening." Obviously, the conclusion is not favorable to surgical interference.

The deductions which one can properly make from careful study of these recorded cases are that in a given case presenting signs and symptoms of brain-tumor, with such local symptoms as indicate that its situation is in or near the cortex of the hemispheres, trephining is indicated,

FIG. 443.



Sarcoma developed between the hemispheres, posteriorly (U. S. A. Museum, No. 8400).

especially if, after a careful antisyphilitic treatment has been carried out for several weeks, there be no improvement, and if there be also no symptoms or signs indicating multiple tumor, particularly in tubercular cases.

Seguin[1] believes that before operating for brain-tumor diagnosis should be carefully made out along five different lines of inquiry, some of which have been already considered:

1. Diagnosis of location, whether or not in or upon the hemispheres;
2. Determination, if possible, of exact location;
3. Determination as to whether cortical or subcortical;
4. Determination of the solitude or multiplicity of lesion;
5. Estimation of its character.

1. The first is based on the gradual development of symptoms, such as headache, convulsions, local or general paralysis, extension of these

cases no tumor had been suspected. The remaining 20 had been more or less mistaken, and probably would never have been brought to the operating table. Only 8 of the entire number were regarded as operable.

[1] *Am. Journ. Med. Sci.*, 1886, July, August, and September.

symptoms, moderate anæsthesia due to choked disk, hemianopsia, stupor, nausea, coma, and slow pulse.

2. To aid in the second point we have seldom, if ever, direct localizing phenomena, the patient exhibiting only general cerebral symptoms. This is particularly true of the frontal lobes, except the caudal extremities of the external gyri, more especially the second and third; in the apex and base of the temporal lobe on each side and in the middle of the lobe upon the right side; the external and basal aspect of the occipital lobes; in some parts of the parietal lobes and the central ganglia. The commissural fibres are also included among the inexcitable parts.[1] *Per contra*, in the cerebrum we have an excitable motor-zone in the cortex with the attached fasciculi and the known sensory zones, in which new growths will cause localizing phenomena. Or, to be more specific, tumors of the caudal extremities of the third frontal gyrus upon the left side in dextrous persons produce, at first, slowness of speech and paroxysmal motor aphasia. As they extend toward the centre of the zone they cause paresis and convulsive movements of the tongue, the face, and the upper extremity upon the opposite side; later still, motor aphasia, spasmodic movements, paralysis of the tongue, face, and upper extremity, with occasional spasms. Tumors of the basal ends of the pre- and post-central gyri cause, first, convulsive movements or paresis, or both, of the opposite half of the tongue; later, paroxysmal motor aphasia, spasm, and paresis of the face and upper extremity; and lastly, complete paralysis of one half of the tongue, of the face, and upper extremity, and permanent aphasia, with occasional Jacksonian movements. Tumors of the caudal extremity of the second frontal convolution where it merges into the pre-central gyrus produce, at first, paresis or convulsive movements of the facial muscles of the opposite side. Later, there is the addition of more or less motor aphasia, hemiparesis of the tongue, paresis and spasm of the upper limb—the fingers, particularly—and lastly, permanent paralysis of the face, half of the tongue, and of the hand, with permanent aphasia and occasional spasms.[2]

Tumors originating in the lower middle third of the pre-central gyrus first show themselves by spasm and paresis of the opposite thumb and finger, perhaps the whole hand and forearm. This deepens into paralysis with irritative symptoms in the face and tongue, while pronounced subjective numbness and slight tactile anæsthesia mark this form of growth. Tumors of the upper middle third of the pre-central and post-central gyri cause only symptoms in the muscles of the upper arm and shoulder, which extend to other parts as the growth extends. Tumors of the upper third of these convolutions and of the pre-central lobule cause the following symptoms: First, paresis in the opposite leg or foot; later, by extension of morbid growth, there are symptoms in the arm and hand

[1] Dr. Starr has recently related to me a recent unpublished case of a venous tumor, probably cavernous angeioma of the dura, situated back of the Rolandic fissure, which was removed with very little laceration or disturbance of the cortex, with rapid recovery. It was found that there was complete loss of muscular sensation on the opposite side. This may show that the muscle-sense has its centre in a region distinctly different from that governing ordinary motor functions.

[2] In the *Charité Annalen* for 1893, Oppenheimer has reported eight cases, going to prove that the area on the right side, corresponding to Broca's centre on the left, has to do with the sense or sensation of music. He also shows that amusia may be present or absent without any reference to the existence of aphasia or any form of amnesia.

and face, probably never aphasia, except where the growth attains colossal size. Or there may be invasion of the crura or centres of the opposite hemisphere, thus producing a sort of periplegia.

TUMORS OF THE SENSORY ZONE.—The centres best known to us are those for half-vision and audible speech, and tumors here show themselves almost exclusively by irritation-symptoms, of which latter we have but little knowledge. As, for instance, a patient with verbal deafness, with marked hemiplegia, probably has a tumor involving the left superior or dorso-temporal gyrus, which, as it grows, would involve loss of muscle-sense, and later anæsthesia of the opposite side of the body. A patient who has headache, vomiting, choked disk,[1] stupor, increasing hemianæsthesia, with lateral hemianopsia (dark half-fields on the same side as the anæsthesia), without hemispasm and hemiplegia, quite certainly has a tumor in the white substance of the occipital lobe. If with general symptoms of cerebral tumor we note hemianopsia alone, there is almost always a tumor on the inner or mesial aspect of the occipital lobe opposite to the dark half-fields, which by downward growth may cause cerebellar symptoms.

3. Determination of the depth of a tumor is difficult, and will be made out by studying the nature and location of the signal symptoms, the presence and order of appearance of spasm or paresis, the presence or absence of headache, and local changes in temperature.

4. The diagnosis of solitary tumor or multiple tumors must also remain necessarily doubtful. If occurring in a tubercular individual, it is probable that the secondary cerebral deposit is multiple. When different cerebral centres and systems are involved, and if we have coincident symptoms of basal disease with injury, it is probably a multiple lesion with which we have to deal.

5. As concerns the nature of a tumor, while one might operate in the case of tubercular focus, even in the presence of similar disease elsewhere in the body, one would hardly think of it in the presence of recognizable cancerous growths elsewhere in the system. Consequently, the search should be made to exclude other lesions of the same character elsewhere in the body. Hutchinson[2] was the first to call particular attention to the importance of the pupil as an indication of intracranial pressure. According to the statistics of Weissman, when marked dilatation of one pupil occurred it was 20 times out of 24 in the seat of the extravasation or lesion. Along with this there were other concomitant paralyses of the external ocular muscles. So in the case of hemorrhages, sometimes pupillary dilatation will be almost the only evidence as to the side upon which hemorrhage has occurred, and will perhaps be the most reliable guide to trephining.

According to Horsley,[3] a so-called "suspicious case" of brain-tumor

[1] According to Naunyn and Falkenheim (*Ueber Hirndruck*, Leipzig, 1882), choked disk depends not so much upon the intensity of brain-pressure as upon the duration of the same. In very rapid increase of the former, as in hemorrhage or hæmatoma of the dura and rupture of the middle meningeal artery, or under other circumstances where exudation or pressure occurs rapidly, and where there is a rapid increase of cerebro-spinal fluid, symptoms of neuro-retinitis may occur and quickly subside in whole or in part. *Vide*, also, Wilder, "Optic Neuritis as a Sign of Brain-tumor," *Chicago Med. Recorder*, May, 1894.

[2] *London Hosp. Rep.*, vol. iv. p. 20.

[3] *Brit. Med. Journ.*, Dec. 23, 1893.

is one which manifests localizing symptoms. These are divisible under Jackson's classification either as over-action or want of action. The chief symptoms of over-action are attacks of Jacksonian epilepsy, not infrequently heralded, even in cases of very limited lesion, by a generalized fit of complete loss of consciousness or by local contractions, which are often rhythmically arranged, or by subjective sensations, chiefly tactal, sometimes local, and obtaining the title of "auræ," although frequently present for considerable time and not necessarily immediately preceding a convulsion.

The chief symptom of want of action is that of progressive motor paralysis affecting one region of the body, or progressive sensory paralyses affecting special sense-organs of one side, or a progressive combination of both. While it is generally held that one or all three of the reputed cardinal symptoms of brain-tumor—namely, optic neuritis, headache, and vomiting—are present, still, these are not of such essential importance as to justify excluding from the class of suspicious cases those which present the other symptoms. In Horsley's first case of cerebral tumor upon which he operated there was neither optic neuritis, vomiting, nor headache; and this exemption is quite frequent. Consequently, to wait for them is a mistake. The one direct feature which should lead the clinician to suspect the presence of a tumor is the progressive character of whatever symptoms may be present. Errors of diagnosis can be usually avoided by the method of exclusion. Inasmuch as the appeal to surgery is usually made when these cases are beyond hope,[1] it is most important to know how long it is justifiable to go on treating suspicious cases with potassium iodide. Horsley holds that this treatment should not be prolonged beyond six weeks, unless striking improvement occur meantime; Starr has put the limit at three months. It is everywhere admitted that no other cerebral tumors are curable by drugs except gummata. Horsley claims that even these are not really cured by drugs, and that no one has ever proven by postmortem records that they do thus disappear. He calls attention also to the interesting fact that, for some unexplained reason, potassium iodide in large doses will often cause a temporary abatement in the symptoms of ordinary tumors, even of glioma, but that this abatement is only moderate, and not to be compared with the effect produced by the same drug on syphilitic lesions. Consequently, temporary improvement under iodide is really no index of the nature of the case. With reference to tuberculous nodules, every one must have seen cases in which all the symptoms of local tuberculosis were present, in which total remission of the same occurred, and the patient ultimately survived, although usually remaining blind, while on autopsy these nodules were found in the fibres with caseated centres. Clearly, then, in certain tuberculous cases internal treatment is justifiable for a certain time, whose duration may be longer than in the other instances—perhaps four months as against two.

The limitations of the subject and the space at command do not permit going more particularly into the matter of diagnosis and cerebral

[1] Bramann ("Ueber Extirpationen der Hirn Tumoren" (*Verhandlungen der Deut. Gesellschaft f. Chir.*, 1892) has demonstrated the possibility of extirpation of large tumors, having removed one from the hemisphere which weighed 280 grams, the patient recovering.

localization. There are now so many monographs and works dealing with this that the omission will be more readily excused. Among these works we refer the reader to the following: Decressac, *Chirurgie du Cerveau;* François Franck, *Fonctions motrices du Cerveau;* Ferrier, *Functions of the Brain;* the monographs of Bramwell and Knapp on *Intracranial Tumors;* Gowers, *Diseases of the Brain and Spinal Cord;* Horsley, *The Brain and Spinal Cord;* Starr, *Brain Surgery;* Ladame, *Diagnostik der Hirngeschwulste;* and the monographs of V. Bergmann, already so often quoted.

Brain-tumors are operated on for two purposes: First, for relief of distressing symptoms in recognizably incurable cases; second, for radical cure. As an illustration of the former I would cite the instance of a woman well advanced in life, with a positive diagnosis of intracranial tumor, although its exact location could not be made out with equal certainty. At all events, it was recognized as being basal and altogether too deep to warrant any attempt at removal. The principal feature of the case was distressing cephalalgia, for which purpose, with the co-operation of her physician, Dr. Putnam, I made a large trephine opening on each side over the area of which she most complained. The dura was not opened, but the relief of pain was very great. She died some months later, her life having been, apparently, prolonged by the mere cessation of her suffering. No autopsy was permitted, and I am to-day in doubt as to its exact location. Nevertheless, of the relief afforded there was not the slightest question. So in every other case when pressure-symptoms become too severe, and especially when the pain is localized to a reasonable extent, it will be quite justifiable to make such openings, large or small, as the case may be, and with reasonable expectation of benefit.

In this position I am sustained by the weight of Horsley's authority, although Bergmann takes the opposite position. In fact, Horsley has shown that the effect of opening the skull is not only relief of pain, but sometimes it seems to produce a remarkable effect upon optic neuritis, so that the swelling of the tissues diminishes, and often steadily subsides, providing atrophy has not already occurred. In other words, restoration of sight to at least a partial degree may be the gratifying although temporary result which follows, and will alone repay for a serious operation. So far as vomiting is concerned, it is so dependent upon the degree of tension that the amount of relief afforded by operation must always be problematical. There has often been fair recovery of power after hemiplegia. Finally, it is claimed with justness that certain new growths are so interfered with in their nutrition by opening the skull and suddenly altering the pressure within that they commence to degenerate. This is a parallel to what occurs frequently in the peritoneum under similar circumstances, and is in harmony with the well-known tendency of all cerebral growths to undergo degeneration.

Removal and Cure of the Neoplasm.—These, of course, are the first objects of operation, if it be possible to achieve them. There is no doubt but that innocent tumors are curable by operation. The reason why so many gummata are ordinarily incurable is to be found in the certain degree of pachymeningitis around them and the progressive and inevitable infection of the meninges. Consequently, the only hope

of curing cerebral gumma is by removal, which ought to be undertaken unless there are evident symptoms of multiple tumors.

Operative Technique.—So far as the tumors which spring from the bone are concerned, and which involve the brain secondarily, the cases on record show that it does not seem to have given patients any serious inconvenience to remove large areas of bone and to cover the exposed brain by plastic or osteoplastic methods. Even when it has been necessary to resect a portion of the superior longitudinal sinus, this has seemed to cause no disturbance in the healing process. In general, however, and for the removal of brain-tumors, the osteoplastic method of raising a flap, suggested by Wagner and modified by Chipault and others, is a measure not often to be adopted, for reasons which may be considered under two headings:

A. Harm to the patient. From both experimental and clinical evidence it is obvious that hammering the skull increases the shock; and inasmuch as all these methods are connected with the use of the chisel—save in the rare instances where a revolving saw can be resorted to—production of shock from this source is excessive. While the Germans and the French resort to it more or less, the English and most of the American surgeons are opposed to it, and most writers at home have expressed their firm conviction that it is an added element of considerable danger. This is my own conviction as well.

B. It is certain that the pericranium has no osteogenetic power; consequently, it is a matter of no importance whether it be retained in contact with bone or not. Further, when the dura has been affected it is to be cut away, and it is not then possible to replace the bone. Horsley believes in the practice adopted by American surgeons of returning large portions of bone, if any, and not in cutting them into small pieces like grafts. If an osteoplastic method must be resorted to, in the absence of the revolving saw the use of powerful bone-forceps after the preliminary trephine opening will probably be most judicious. In the earlier operations a large number of patients died from shock. This we have learned to avoid by the simple expedient of dividing the operation into two stages, consisting first in exposure of the dura by removal of the bone, which may be followed a week or two later by whatever further operation may be indicated. It is extraordinary how little shock attends removal of the tumor in the second stage of such a divided operation. Bergmann and Horsley both believe thoroughly in the great advantage of packing the cavity left by removal of the tumor; in fact, the gauze tampon seems to be one of the most valuable expedients within reach of the surgeon. Immediate ligation of all spurting arteries after enucleating a tumor is wise. The tampon should be reserved for venous oozing. We may cut into the brain to the depth even of 4 cm. without an artery spurting, except possibly from the pia. If in the removal of a tumor from the occipital lobe, for instance, we should happen to injure a large branch of an artery like the posterior cerebral, it should be immediately sought for and tied. The advantage of tamponing may be illustrated by one of Horsley's cases, in which, for instance, after shelling out a tumor with great ease, the patient recovered from the anæsthesia and from the shock, but began to vomit five hours later, and ruptured a small blood-vessel within the wall of

the cavity, so that the head filled with blood, which passed through the softened tissue into the lateral ventricle. Then it passed rapidly down to the fourth ventricle, where it caused death by pressure upon the respiratory centre. This unfortunate accident could have been avoided had the cavity been left plugged for twenty-four hours.

This tampon should be made of sterilized gauze into which powdered iodoform has been rubbed, since the latter helps to control hemorrhage. My own preference would be to use for this purpose gauze which had been soaked in a 3 to 5 per cent. solution of antipyrine and then dried before sterilizing or using. With such gauze even bleeding from the pia in dressing compound fractures may be controlled. The best method of using it is to place a crumpled piece in the cavity, on top of this a second, then a third, etc. If now a skin-flap has been made, it should be turned back, and the usual antiseptic dressings applied over it and over the gauze, which should project beyond the margins of the wound. This outside dressing should be so absorbent that it may take up everything which may come to the surface by way of the deeper gauze, which in this way will remain comparatively dry. If, however, only a strip be placed in the bottom of the wound and allowed to protrude through an opening left by incomplete suture, this strip, intended for purposes of tamponing, soon becomes so saturated that it cannot absorb any more; and consequently the blood and transuded serum will accumulate around and behind it, while that which protrudes between the edges of the wound will be compressed and consequently interfere with free outflow.

In addition to the above, the writer recommends having at hand a few old-fashioned serrefines, properly sterilized, which can be resorted to, if necessary, for securing vessels which may not be easily tied, and which can be left, along with the tampon before spoken of, until the third or fourth day if necessary, when all may be removed together. These will be more serviceable than the ordinary hæmostatic forceps, whose handles are too long. These will be particularly useful in case a sinus be opened.

Next to the danger from hemorrhage comes that from the development of acute and rapidly fatal œdema, which may be brought about in two ways:

1. By increased tension in the arterial vessels; and,
2. Through venous stasis.

The former is the force which operates to produce more rapid formation of cerebro-spinal fluid; the latter is the influence which especially produces œdema. In the latter case we have infiltration of capillaries, which is much more potent for this purpose than increase of arterial pressure. Venous stasis produces also lymph-stasis, by which collection of fluid in the tissues is still further facilitated. The combination of the two influences may quickly produce œdema. When these operate along with hyperæmia in some part of the brain, the result of the removal of bony walls and accumulated counter-pressure, we may look for speedy disastrous results. It is the veins which are most apt to become dilated upon removal of their natural supports. Magendie's old experiment of exposing the occipito-atloid membrane, making a small opening in it, allowing the cerebro-spinal fluid to escape, closing it with the finger for a few moments, and then observing what a stream will escape again, is

most demonstrative as concerning the rapid collection of this fluid. The most potent factor in causing reabsorption of this fluid is intracranial tension. When this is diminished by operation the spread of cerebral œdema is greatly favored.

Secondary hemorrhage, difficult of control, may be the result of the removal of brain-tumors, and may be added to the danger from œdema. When a tumor of the brain has already produced serious cerebral disturbances, coma, etc., we shall be quite sure to find extensive œdema on autopsy. On this account Bergmann regards the attempt to remove such tumors during the comatose state as entirely hopeless, since the œdema will become worse as the result of operation, and in a few hours will increase to an extent incompatible with life.[1]

Therefore, it will be wise to limit further operation to those cases in which, after exposure of the tumor, it may be found favorably situated. This discovery may require an exploratory incision into the white substance of the brain, but the operator should be willing to stop here in case he finds the tumor too large or widely infiltrated. Hence evacuation of cerebral abscess and extirpation of cerebral tumor stand in somewhat opposite relations. In the former diagnosis is difficult, but surgical technique usually adequate; in most tumors amenable to surgery diagnosis is rarely difficult, but our technique extremely limited.

Bergmann also calls attention to the peculiar relations of the bones of the skull, which are often important for the study of cerebral pressure. In case-histories there is often mentioned tenderness over the growth. On examination there is frequently found a thinning out of the bone at certain places, where it may be as thin as parchment and quite fragile under the finger. These thin places are, for the most part, not direct effects of the tumor, but indirect pressure-effects.[2]

Fracture of the Nasal Bone.

These fractures may involve one or both bones alone or the neighboring osseous and cartilaginous structures, such, for instance, as the vomer, the nasal processes of the superior maxillary, the lachrymal, etc. They are almost invariably the result of direct violence, and may be simple or compound, single or multiple. The most serious complication of these fractures is that of the ethmoid bone,[3] the cribriform plate of which is sometimes involved. Usually there is more or less displacement of fragments, either backward or laterally, or both. When violence is transmitted backward the perpendicular plate of the ethmoid will either yield without fracture or will break without transmitting violence. Injury to it, therefore, is insignificant, while lesion of the cribriform plate is of course much more serious. In many so-called

[1] Of 19 fatal results of operation for brain-tumor collected by Beck, death resulted in 13 instances during the first twenty-four hours after operation, 3 times from hemorrhage, once from acute sepsis, 5 times from acute meningitis. The other 6 cases died within a week or two, 2 of them from tuberculosis, 4 from purulent meningitis.

[2] *Vide* also "Discussion on Intracranial Surgery," *Edinburgh Med. and Surg. Journ.*, 1894, April to June.

[3] Boyer (*Journ. de Méd.*, Paris, Aout, 1766), Jacobson (*Holmes' System of Surg.*, vol. i., p. 581), and Marmy (*Bull. de la Soc. Anat. de Paris*, 1848, p. 258) have described fractures of the ethmoid bone alone—the first and second due to falls on the frontal; the third, to a fall on the feet.

"broken" noses the fracture is really a separation of the nasal cartilages from the bone.

The features accompanying nasal fracture are—first, a history of violence; second, actual hemorrhage or evidences of it—bleeding, in fact, is often serious and difficult of arrest; and, thirdly, emphysema of the surrounding parts of the face. This may sometimes be quite extensive and temporarily disfiguring, giving rise to no little alarm upon the part of the patient. There is also occasional obstruction of the tear-duct. Almost always there will be sufficient obstruction from blood-clot or swelling of the mucous membrane to make nasal breathing difficult or impossible. Later, abscesses may form in or about the nose as the result of infection.

Save for the æsthetic considerations involved, fracture of the nose would be, ordinarily, a trivial injury, except in rare instances where it is simply an external accompaniment of severe fractures of the skull. The feature about which patients are ordinarily most anxious is possible disfigurement, to the correction of which they are willing to sacrifice almost every other consideration. When these cases are seen early it is usually possible to avoid much deformity. When seen late. however, this may be impossible. In such cases, should the parts not yield readily to comfortable pressure, it would be well to anæsthetize the patient and to make a complete but forcible reposition of fragments. When accurate reduction has once been made, it is quite possible to maintain the normal appearance without any external support of any kind. This is particularly so with tractable patients. Unfortunately, a desire to handle the part or the frequently almost constant desire to blow the nose, due to internal irritation, may make it difficult to avoid some support. For purposes of reduction frequent manipulation from the exterior alone, or a combined manipulation with dressing forceps or some such instrument internally, may be necessary. The finger is for almost all purposes too large, and the attempt should not be made to introduce it. Should these not be enough, a very small chisel may be introduced from within, by means of which complete separation can be effected.

The fragments after replacement may be supported by internal pressure, as by plugs of gauze, either rolled firmly or rolled around tubes of some kind. The presence of such tampons gives rise to considerable discomfort, and may not be well borne. It would probably be more comforting for the patient to make such hand-pressure several times a day as would be necessary to maintain position, feeling that the parts would become secure in position within two or three days. In certain cases it would be possible to mould a thin piece of gutta-percha or some other plastic material into an external splint, which may be held in place by strips of plaster or by some other expedient. Should there be constant tendency to drop backward, there is no expedient so satisfactory as that suggested by Mason, who transfixed the nose with a needle or hat-pin just below the fragments, and used this as a bridge upon which to support the fragments, the ends of the needle being protected by cork or some other material. This needle is left in place for a week or so, after which it may be withdrawn without pain.

Such complications as excessive hemorrhage, which may require complete tamponing of the nostrils, and emphysema or contusion of the

overlying skin, may be treated in the conventional way, taking pains merely to avoid infection.

The surgeon will be occasionally approached by men suffering from displacements due to previous injury, for whose correction his aid is sought. In many of these instances it will be possible by small incisions and the introduction of small sharp chisels to separate the bones along the lines representing the original fracture, and then, by resorting to Mason's expedient or in some other way, to brace the loosened nose and hold it in position while the process of repair proceeds to consolidation that will warrant removal of the splints.

Fractures of the Zygomatic Arch.

These are essentially the results of external violence acting from without, the displacement usually following the direction of the force, and the line of fracture being most often found in the temporal portion of the arch. Should the case be seen early, before exudation or hemorrhage has produced swelling, there will often be seen a depression or flattening of the cheek in that portion occupied by the arch, while with the palpating finger the irregularity of the bone can be readily made out, especially by contrasting the injured and the uninjured sides. If there be marked depression, it can often be ascertained with the finger in the mouth. Mobility and crepitation are often demonstrated by movements of the jaw.

Sometimes the violence has been great enough to produce fractures as well of the floor or external margin of the orbit, in which case there will take place, within a few hours, extravasation of blood, which may produce exophthalmos or at least a subconjunctival ecchymosis.

When the origin of the masseter is thus severely interfered with, motions of the jaw will be found painful, perhaps impossible. It may also happen that the play of the coronoid process is interfered with, or that of the temporal-muscle tendon. There is at least one case on record where the coronoid process was broken by the same blow that fractured the arch.

These cases will not often permit of complete reduction of fragments unless there be a wound of the skin. Should it appear that serious disadvantage will result from this condition, it would be perfectly justifiable to make an opening under aseptic precautions, and with suitable instruments draw the displaced arch into position, securing it there, if necessary, either by drilling and wiring or by temporarily fastening the bone with silver wire to some external support. Stimson has briefly described one recorded case, and the only one, in which displacement seriously interfered with movement of the jaw. In this the difficulty steadily increased until the patient could barely separate the teeth. Then, one morning, while yawning, he felt something snap, and the motion of the jaw at once became and remained free.

Injuries and Diseases of the Frontal Sinus.

The injuries to this sinus have already been considered in connection with other injuries to the skull, and will be found treated of on page

616. The most common diseases of this sinus are those produced by extension from the adjoining nasal cavity, and of these by all means the most frequent is that which is generally known as "empyema" of the sinus. This may be of primary origin, and of 48 cases studied by Richards,[1] in 3 instances the obstruction was of this acute character; 4 times polypi and similar growths were found. In 14 instances the disease seemed to be the outcome of blows, falls, and similar injuries. In about 50 per cent. of the entire number the history failed to give any explanation for the condition. In acute cases the empyema is due to direct accumulation of pus, which results from apparently the conversion of a catarrhal into a purulent inflammation. When the disease is of milder and slower type, we have obstruction of the infundibulum, due to alteration of the mucous membrane and plugging of the infundibulum, with subsequent distention. The obstruction of the Schneiderian membrane —for such it practically is—may lead to subsequent disease of the bone or periosteum, even to the extent of producing necrosis.

When the frontal sinus is distended by retained fluids, it yields first in the direction of least resistance. Consequently, the first swelling is at the expense of the orbital cavity and at the root of the nose. In most instances this swelling is unilateral, since disease of both sinuses is extremely rare, and is, for the most part, limited to those individuals in whom the septum separating the two is deficient.

The principal **symptoms** are local tenderness, pain—frequently referred to the distribution of the supraorbital nerve—frontal headache, more or less nasal obstruction, and discharge of mucus or pus; sometimes there is lachrymation. Naturally, the severity of all these symptoms will depend upon the acuteness of the case. Chills, pyrexia, and general malaise are usually complained of, and, should perforation have occurred posteriorly, we may have evidences of septic meningitis. In the more chronic cases, when bone has been absorbed as the result of pressure, we may get a fluctuating tumor in the above region, with or without displacement of the globe. The nearer the pus approaches the surface the more superficial evidence thereof will be noted in the manifestation of redness and œdema, with pitting on pressure. In fact, the disturbances thus produced have been mistaken for commencing erysipelas.

In certain cases serious eye-symptoms have been the indirect result of disease of the frontal sinus—not merely diplopia and ptosis, but even intractable iritis or disturbances of the uveal tract. In addition to the septic meningitis already spoken of, in slower cases brain-abscesses have resulted from posterior perforation, or widespread and deep necrosis.

This condition, when existent, must be treated surgically. In some instances it is possible to reach and catheterize the infundibulum through the natural passages; but even for this purpose it is almost invariably necessary to cut away, with the snare or burr or forceps, a portion of the turbinate bones in order to expose the opening of the sinus. But in almost every instance it will be found advisable to make opening from without in order to thus expose and drain the cavity. Dawbarn[2] has succeeded in passing from the external opening a pe-

[1] *Journ. Am. Med. Ass'n*, 1890, vol., xiv. No. 13.
[2] *Reference Handbook*, vol. ix. p. 342.

culiarly bent probe, down through the natural passage into the middle meatus, and out through the nostril, to which may be tied a silk thread, by means of which, when withdrawn upward, a small drainage-tube or strip of gauze may be secured as a drain. The incision for this or any other method of opening the sinus may usually be made within the limits of the eyebrow in such a way as to leave a minimum of resulting scar. It is usually very much more satisfactory to drain this sinus from the frontal region than from the orbit. Transillumination of the face by means of a small electrical light placed in the mouth has been known to be of service by demonstrating a greater obliquity upon the diseased side than on the other. Nevertheless, it is scarcely necessary to make out the exact limits of this sinus, providing only that the condition be recognized.[1]

In two instances coming under the writer's care within the past few months there have been present polypi, from upward extension of similar trouble in the nose. In each case the frontal sinus was distended, so that it would hold at least 20 c. c. of fluid, and each called for somewhat extensive incision, curetting, and cauterization.

The principal other affection of this sinus is that due to the presence of tumors, of which only the osteomata need particularly concern us here. These are essentially slow in their development, give rise to the same symptoms of expansion and pressure as do the collections of pus, but are free from all signs of inflammation or infection. Many of them acquire considerable size before causing any serious complaint of pain. In rare instances frontal headache or referred pains may be met with early. These growths, like any other, are to be attacked surgically, but always with caution and with some reservation in the direction of prognosis. According to Kikuze,[2] 33 per cent. of 54 operated cases died of deep infection. Evidently, then, the operative procedure is a serious one, and it is most important to make it as early as possible. No particular directions are necessary, and none can be well given, since in each instance the lines of incision and the extent of attack must depend upon the case itself. As it is not at all unlikely that the dura may be exposed, possibly opened, it will be seen that there is urgent reason for rigid aseptic precautions.[3]

Foreign bodies which are met with in the frontal sinus are generally parasites which have crept up from the nasal cavity, and these, for the most part, are insects, which may either die there or may deposit larvæ which will hatch and live. It is even said that centipedes have been found within the frontal sinus. Danger comes not so much from adult insects as from larvæ, which may destroy the mucous membrane and possibly cause necrosis of the nose. A cellulitis of the external parts has even followed this disturbance, with an erysipelatous œdema of the skin sufficient to close the eyelids. In other cases empyema has been produced. In the tropics this condition is not infrequently fatal. Douches of antiseptic solutions and inhalations of chloroform vapor or

[1] See also *Revue Internationale de Rhinologie*, 1893, p. 246; also "Memoirs of Guillemain," *Arch. d'Ophthalmologie*, 1891; Dercheu, *Thèse*, 1892; and Luc, *Archiv. Internat. Laryngolog.*, 1894, vii. p. 185.

[2] *Centralblt f. Chir.*, 1888, No. 36.

[3] *Vide*, also, Banga, "Osteom des Sinus frontalis," *Deutsche Zeitschft. f. Chir.*, iv. 486; Nakel, "Ein Fall von Stirnhöhlenosteom," *ibid.*, xxxiii. 308.

of a solution of iodine in chloroform furnish about the only method of checking such parasitic life, short of operative measures.

The Ethmoidal and Sphenoidal Sinuses.

Disease of the ethmoidal cells differs essentially from that of other accessory cavities of the nose, because the ethmoid cells are complicated in construction, while the maxillary, frontal, and sphenoidal sinuses are single cavities. In the latter a single opening answers for irrigation and drainage; in the former it is impracticable; in the ethmoid we must break down partitions before making a single cavity. So-called "ethmoidal disease" usually means suppuration and empyema. Acute ethmoiditis is known, and is likely to follow attacks of grippe. Bosworth[1] has shown that we have to deal mainly with three different lesions of these cells:

1. Extracellular myxomatous degeneration;
2. Intracellular myxomatous degeneration;
3. Purulent ethmoiditis.

These conditions are frequently merely successive stages of one affection. As the result of the degenerations we have polypi springing from this region—perhaps filling or distending the ethmoidal cells, and finally projecting into the nose, when pus finds its exit either anteriorly or posteriorly, makes its way into one of the nasal chambers through one of the numerous openings, and appears either beneath the first turbinated bone or between it and the septum above. From here it may make its way into the lower meatus and be expelled anteriorly. When it escapes posteriorly it empties most often into the larynx, dropping into the throat and causing a condition frequently confused with naso-laryngeal catarrh. Occasionally this pus makes its way through the os planum into the orbital cavity, giving rise to exophthalmos and orbital cellulitis. The former may also be produced by distention of the cells without escape of pus. The much-discussed necrosis of this bone occurs relatively seldom. Zuckerkandl, contradicting Woakes, states that he has never seen caries of these cells.

In the **treatment** of these cases in the earlier stages we can do little but frequently irrigate with hot saline solution, which should be used copiously. When the disease has reached the chronic stage surgical interference is almost always required, the object being to relieve intracellular pressure and to afford drainage by uncapping the ethmoid cells. The projecting turbinate may be removed with the snare or engine until the mucous membrane within the cells is exposed. When they contain more or less pus the principal problem is to convert a number of small cells into one large cavity and drain it thoroughly. For this purpose more complete removal of the turbinates is necessary, after which the trabeculæ are broken down by the same means. The possibility of drainage thus established is utilized to any necessary extent. Knapp[2] thinks that sometimes the ethmoidal cells may be opened from the middle sinus, where a pointed instrument at the hiatus semilunaris will naturally penetrate into the anterior part, producing often an opening large enough for evacuation of liquids and subsequent irrigation. But

[1] *Med. Rec.*, 1894, Oct. 13, p. 45. [2] *Journ. Am. Med. Ass'n*, 1893, Dec. 2, p. 842.

when the cells *in toto*, and particularly when the sphenoidal also, are involved, complete removal of the upper turbinate seems to be absolutely necessary.

Another method of operating is from the orbit by curvilinear incision, which has the advantage of permitting a clear view of the diseased parts, which can be thus readily exposed, punctured, or excised. An opening into the nose may be then made from above downward. In this operation division of the frontal nerves gives more or less anæsthesia of the forehead, which, however, is of no consequence. Injury to the superior oblique muscle would produce diplopia, and must be avoided; but when the os planum is displaced and the lower wall of the frontal sinus encroached upon, the pulley of the superior oblique is so far drawn away from the nose that a curvilinear incision close to the orbital margin will not interfere with it.

Symptoms of ethmoidal disease are, for the most part, headache, exophthalmos, gradual or rapid loss of sight, mouth-breathing because of partial nasal obstruction, diplopia, dacryocystitis, with possible pressure-signs of optic veins, as shown by the œdema, or even optic atrophy. Periodic œdema of the subconjunctival tissue, with possible signs of orbital cellulitis, sometimes occurs, with more or less protrusion of the eye. To be sure, these same signs may also be caused by inflammation of the sphenoidal sinuses. Consequently, the symptoms mentioned above are more or less common to disease in both locations.

The sphenoidal sinuses are much oftener affected than is generally suspected. Disease of this sinus is difficult of diagnosis, because of concealment of the cavity, and because retained secretion must practically fill it before it can escape by the natural opening. Herzfeld[1] has studied forty-six cases of this character. The symptoms are far from being pathognomonic. Patients very often complain of dizziness and of specks floating before the eye, particularly when they are for a long time in a warm room. The overflow of discharge and the cephalalgia which nearly always accompanies this condition are often complained of, especially before menstruation. This may be accounted for possibly by the well-known fact that the erectile tissues within the nose frequently become congested during menstruation, and that is possible to have vicarious hemorrhage from these sources. The pain complained of is usually vague, its location not easily explained, and it is probably due to direct irritation of nerve-ends in caries of almost all the parts above the nose, whether of the walls of the sphenoidal or of the ethmoidal cells. Patients complain usually of a boring, gnawing pain inside the nose, but seldom make the complaint more definite than this. Escape of purulent material helps in diagnosis, since it may occur in empyema of the accessory cells or sinuses. It is of importance that the anterior walls of the sinus become very fragile and are easily perforated by the probe. One of the most significant signs is a circumscribed swelling of the septum at that point where it borders on the anterior margin of the sinus. Here the mucous membrane will be found elevated and pitting on pressure with the sound.

So far as causes are concerned, we may say that the sphenoidal sinus becomes involved as the result of the same agencies which produce simi-

[1] *Arch. f. klin. Chir.*, vol. xlvii. p. 146.

lar disease in the other canals adjacent to the nose. Weichselbaum found that the frontal and maxillary sinuses of those dying of influenza were frequently involved, and Liebermann found the same condition of the maxillary antrum after typhoid and influenza. Extension of cellulitis or erysipelatous inflammation into these deep cavities is also known. I have found no recorded case of parasitic invasion of these deep cells.

So far as **treatment** is concerned, a writer in the *Rhinologist* has recently taught us how to gain access even to the sphenoidal cells, which, when diseased, need to be exposed and cleansed like any other abscess-cavity. Accordingly, when the above symptoms present the sinuses should be exposed and perforated. The removal of tissue to permit of access will take away usually only more or less of that which is already diseased, which will be a benefit rather than a disadvantage, and is absolutely necessary in order to carry out the ordinary canons of local cleanliness and facility for drainage. When it comes to exploration previous to operation, Laurent has shown[1] that catheterism and exploration of the sphenoidal sinus can be made without any speculum, by showing that the distance from the opening of the sinus in the superior meatus to the nostril is $6\frac{1}{2}$ cm. The extremity of a probe curved at an obtuse angle is introduced into the nose, and carried upward close to the septum, while the shaft is held parallel to the dorsal line of the nose. At the depth of $6\frac{1}{2}$ cm. the extremity of this probe is turned through a quarter of a circle, the handle is depressed, and the sound enters the sinus in an upward and backward direction. This may be done, however, by introducing a sound to the depth of $7\frac{1}{2}$ cm. clear up to the postero-superior angle of the nasal cavity, and then drawing it forward 1 cm. and revolving it through a quarter of a circle.

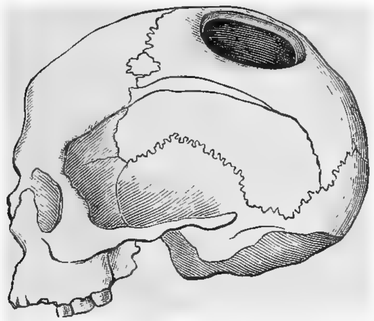
Operations upon the Cranium and Brain not Elsewhere Considered.

To the medical historian or to the earnest student of the art of surgery the history of trephining is one of great importance and interest. To attempt to do it even scant justice would take us beyond the limits of this article. For information in this regard we therefore refer the reader to any or all of the following works: Horne, *Trephining in its Ancient and Modern Aspect;* Gallez, *La Trépanation du Crâne;* Lucas-Championnière, *Étude historique et chirurgique sur la Trépanation du Crâne, La Trépan Guideé par les Localisations cérébrales;* Seydel, *Antiseptik und Trepanation;* and Chipault, *Chir. opératoire du Système nerveux.* In these recent works or in the special works on the history of medicine and surgery one may find many pages of interesting reading. Suffice it here to say that recent researches in Europe conclusively prove that trephining was practised by neolithic men, probably cannibals, who inhabited Europe several thousand years ago, and that it is highly probable that the operation was largely the outcome of superstitious notions concerning epilepsy and insanity. Sharpened shells and flints were the rude instruments employed. In the time of Hippocrates it was a recognized operation, and has been since his day, although waves of professional opinion have given it a variable position among the recognized

[1] *Revue de Laryngologie,* 1894, vol. xv. p. 787.

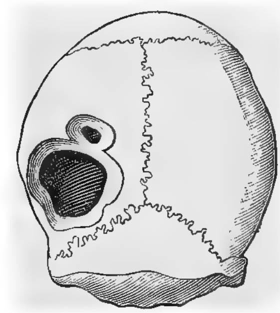
expedients of surgery at different eras. Among many of the savage races even to-day it is practised much as in prehistoric times. Notions at one time prevailed that by the formation of an opening of this kind escape

FIG. 444.



Neolithic cranium (from Feigneux): opening made by a rude saw (Broca collection; Chipault).

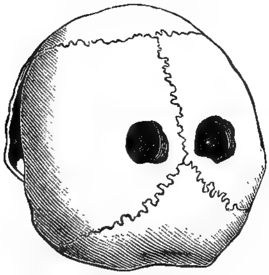
FIG. 445.



Cranium from the dolmens of Lozère, with two trephine openings (Broca collection; Chipault).

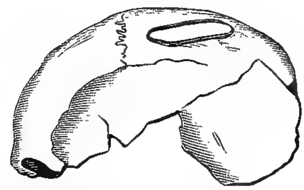
was afforded for evil spirits, and individuals thus operated upon became objects of reverence and were especially regarded. The very few illustra-

FIG. 446.



(From the Broca collection; prehistoric trephine openings; Chipault).

FIG. 447.



Old cranium opened with a saw (Ribeiro collection in Lisbon; Chipault).

tions which we give from Chipault will be of interest in this connection. At one time it was the fashion to make a large number of openings, as it is recorded that Mehée de la Touche made fifty-four trephine openings on one patient, while the case of Philippe of Nassau with his seventeen trephine openings is classical.

It is necessary to call attention to the terminology of surgical literature in this regard. While the words "trephine" and "trepan" are practically synonymous—coming from the Greek *trupan*, to bore—the usual acceptance to-day of their significance is to give the name "trepan" rather to the instrument, while the operation is commonly known as "trephining." This is a matter of custom, however, rather than of accuracy, since to-day the word "trepan" is seldom used, and "trephine" is in common use both as the noun and the verb. By common consent also we have come to speak of almost any operation by which the skull is opened as "trephining," whether this be done with the small circular

saw known as the "trepan" or "trephine," or by means of mallet and chisel, or in any other way.

The operation of opening the skull, or, in general, of trephining, is at present practised for the following purposes:

1. For relief of compression:
   A. By depressed bone, as in comminuted and gunshot fractures;
   B. For removal of clot or checking of hemorrhage;
   C. For evacuation of pus, either from the meningeal cavity or from a deeper abscess;
   D. For the removal of serous effusions, either intraventricular, extracerebral, or œdematous.
2. For removal of foreign bodies;
3. For relief of intracranial irritation—*e. g.* epilepsy, insanity, etc.;
4. For removal of tumors;
5. To compensate for defective development;
6. For empirical reasons, including the making of relief-openings for relief of pain or for exploration in certain unknown intracranial conditions.

In a generic way, operation practised for any of these purposes and by any instrumental means is ordinarily spoken of as "trephining."

FIG. 448.

Trephining in the sixteenth century (from Andrea a Croce).

For the accomplishment of the indicated purposes the operator has his choice of more than one method, and, in fact, an extensive opening of the skull may be done without resorting to the circular saw originally called the "trepan." However, almost all operators use it, at least at the commencement of the operation, for the purpose of making one or

more perforations through which other instruments can be used, and for many purposes a trephine of suitable size will suffice. The instruments supplied in the average operating case are about three-fourths of an inch in diameter; an instrument smaller than half an inch is rarely of use, and they are made and used so large as two inches, or even more, in diameter. The advantage of cutting a larger circle with one of the latter is scarcely enough to compensate for the disadvantage of the extra force that has to be used, the strain upon the operator's hand and arm, and the fact that in cutting so large a circle one is likely to find bone thicker in some places than in others, on which account the dura may be much more lacerated than where other instruments are resorted to. Most operators, therefore, will prefer to make a small opening, and then enlarge it with rongeur or other cutting forceps.

In operating for depressed bone the instrument is usually placed upon an adjacent portion which is strong enough to stand the pressure made necessary during the operation. It will never do to apply the trephine upon the depressed bone unless it be unusually firmly locked with adjoining fragments. Great latitude is permitted so far as the exact point of application be concerned, but when all things are equal it is probably well to make this on that side of the lesion which shall be the lower one

FIG. 449.

Trephining in the sixteenth century (from Andrea a Croce).

when the patient lies upon his back—*i. e.* in the customary position—since by this, should it be necessitated, drainage might more easily result. The incisions in the scalp should also be so planned, when practicable, as to have the base of the flap, providing one be made, upward, and the apex of the flap where gravity may best carry away fluids should they

be discharged. Of course, if there be already laceration or injury to the scalp, the existing openings will be utilized so far as possible.

Before this, as before any of the operations here spoken of, an elastic tourniquet may be applied snugly around the scalp, protecting the ears, perhaps also the eyes, by pads suitably placed. If this elastic cord be drawn snugly enough, it will be possible to make the operation bloodless, so far as bleeding from the scalp is concerned. This will be a help during the operation, though it will scarcely obviate the necessity for exact hæmostasis when closing the flaps after its removal. While I have spoken of provision for drainage, there should be added to this statement another to the effect that with improved technique and the dry method of operating it is much less often necessary to resort to drainage than in former times.

It would seem unnecessary to go into a detailed description of elevation of depressed bone. It should suffice to say that, the first trephine opening having been made, through which elevators, handles of forceps, or other instruments may be introduced, the depressed portions are elevated, using the firm region of bone as a fulcrum, while portions large or small which are completely detached are removed, and those which are semi-detached are removed or left *in situ* according to the extent and firmness of their attachment and the prospect of their receiving enough vascular supply for purposes of nutrition. Spicules and small fragments are invariably removed; sharp corners and edges are cut away with saw and cutting forceps, or, if one be using a surgical engine, with the burr of such an engine. In connection with these efforts to remove all possible sources of bone-irritation there should be a certainty of effort directed toward removal of all shreds and fragments of tissue whose vitality is doubtful, in order that there may be no possibility of subsequent necrosis of tissues, separation of sloughs, and interference in this way with primary repair. This applies also to a mangled and injured scalp, since it would be much better to cut away a certain area of scalp and atone for the defect by some autoplastic method than to leave tissue which might subsequently slough, simply because it seemed necessary to fill the gap.

The operation for removal of clot has already been practically considered under the head of Hemorrhage, especially that from the middle meningeal artery, while the surgical anatomy of that vessel and the directions for finding it will also be found duly considered there. In other respects the removal of clot necessitates sufficient opening and the use of such instruments as may be necessary for its dislodgement. Sometimes a gentle irrigating stream will be sufficient; at other times forceps and spoons, either dull or sharp, may be required. Here, too, more than one opening may be called for, as in the case already alluded to in the author's practice. Sometimes clot becomes semi-organized before operation, and very tenacious, and, while so much of it may be removed as necessary, one need have less fear about leaving little particles which adhere tenaciously.

The possibility of removal of clots, even from the base of the brain, has been illustrated by a case in the practice of Laplace,[1] who has thus placed on record probably the first case in which trephining of the tem-

[1] *Int. Med. Mag.*, 1893.

poral region was done deliberately for removal of clot beneath the brain. In this case he used to advantage an instrument fashioned like a miniature egg-beater, by which the clot was disintegrated and made possible of removal.

The dura when opened should be closed again, if possible. This will call for the use of fine curved needles and catgut which is absolutely reliable. It is not an easy thing to make perfect closure of the dural incision without injuring the underlying cortex or at least its pia. There has been always a theoretical objection against interfering with the dura in any such way, because of the adhesions which are very likely to form between it and the underlying pia or cortex. These adhesions, which are so undesirable as the result of injury alone, are not much less so when due to deliberate interference. They mar, in other words, the perfection of operative technique in this region. For the purpose of obviating this particular objection, which is sometimes of great practical importance, I have often resorted to the suggestion for which I am indebted to Beach of Boston—namely, to insert a piece of *sterilized gold-foil* between the brain and the dura underneath the sutured area. In fact, I have perhaps gone beyond the original plan in its use, and now advise and practise the use of such foil in cases of compound fracture where the dura has been opened, as well as in the various operations where we intentionally incise it. I have never seen the slightest harm come of it, although I have never yet had opportunity to study post-mortem how perfect had been the success thus obtained in preventing adhesions. In theory, at least, it is unobjectionable, and in actual practice it has given, so far, only the best of results.[1] In fact, Estes has gone yet further in its use, and has reported a case of compound depressed fracture with laceration of the cortex, portions of which were lifted out with forceps. Free hemorrhage took place, which was checked by a gauze tampon. On the day following this lesion there had been extensive oozing with some escape of brain-tissue. The wound was re-dressed in the same fashion. Two days later the patient was chloroformed, and, after getting the dimensions of the opening in the bone, a cup was fashioned in thicker gold-foil, which had been sterilized and made into the shape of a hollow truncated cone whose base was just large enough to fit closely to the rim of the inner table, projecting into the brain to the depth of 2 cm. The plugs were removed from the cerebral cavity, the clot washed away, and the cup introduced, apex downward. It was fastened in place by working the metal into the indentations of the bone, and was packed loosely with gauze. The scalp was so loosened on either side that the cup covered the opening. One week later the wound was re-dressed: the metal was firmly held in place, and there was no bulging nor escape of brain-matter. In two weeks the wound was completely closed. The patient was kept under observation for some time, and developed no unpleasant complication, in spite of the remaining metal. Consequently, a new method of dealing with cerebral hemorrhage and of prevention of prolapsus cerebri is offered to us.[2]

The *operation for evacuation of Abscess in the Brain* has already been sufficiently described under that heading. The opening may be

[1] See *Med. News*, Dec. 3 and 10, 1892.

[2] *Med. News*, March 10, 1894, p. 267.

made in any desirable way, can be enlarged to any desirable extent, and here, as elsewhere, one may feel that the instruments of the surgeon, used judiciously, will not do so much harm as will pus left unevacuated. Sufficient directions for tamponing, drainage, etc. have already been given.

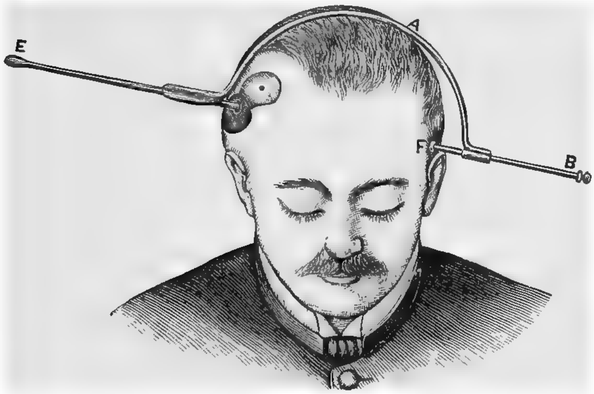
Operation for drainage and irrigation of the meningeal cavity has already been spoken of when dealing with the conditions which lead to the formation of pus in that situation. It needs but little further description here. The condition being a diffuse one, the opening should be so planned as to best permit complete drainage. Consequently, at least one of the openings should be made in the occipital region, and probably on either side of the falx. By these openings drainage will be permitted, but if complete irrigation is to be practised, it will be necessary to make openings in the frontal region as well. These need not be large, and may even be made with a guarded drill, extra care being taken that it be not allowed to perforate the dura. There is more danger of this, however, with the ordinary drill than with the small trephine. Scarcely any fluid could do so much harm as pus, but it would probably be wise to use for irrigation Thiersch's borosalicylic solution or else a not very strong sublimate solution.

Operation necessitated for the removal of foreign bodies is to be based entirely on the supposed nature, extent, and location of the same. The foreign substances most often calling for operative interference of this kind are bullets. While we have deliberately left most of the considerations of gunshot injuries to be dealt with in another article, it will be most pertinent to the subject to illustrate here the methods of detection and removal of missiles. No matter how much a bullet may deflect in its course before entering the brain, the presumption always is that when once it has entered this viscus it will pass straight through it; consequently, that it will impinge upon the skull at a point opposite to that at which it entered. Here it may either perforate and pass out, may remain attached to the bone, or may be reflected and drop into some other part of the brain, where its presence may or may not be indicated by focal disturbances. It is now generally considered wise to trephine not only at the point of entrance, on account of the comminution of the bone, but also at that point, above referred to, upon which it will impinge. The detection of this point has not always been an easy matter. A probe passed into the bullet-track and allowed to find its own way into the brain will seldom go to the complete extent desired without the use of undue pressure or force. The telephonic bullet-probe of Girdner[1] will be reliable when its point comes in contact with the metal; otherwise, it will give no information which the ordinary probe will not. Bryant has recently suggested a method of finding the second point by means of lines drawn meridianally, their common centre being the point of entrance which is known and the point sought, whose location is made known by the place at which these lines converge. Still more recently Morgan of Indianapolis has devised the method figured herewith by the use of a trajector, of which the plate C is applied to the probe, already passed as far as it will easily go along the bullet-track,

[1] *Vide* papers by the writer and others in *Trans. Am. Ass'n of Military Surgeons*, 1895, vol. v.

after which the point *F*—*i. e.* the desired point—will be indicated by the sliding rod *BF*. Providing only that the original probe can be safely introduced to a sufficient extent to give the proper direction, the device is simple and, apparently, accurate. The desired, or second,

FIG. 450.



Morgan's trajector.

point having been determined, the trephine is employed at this point, and after removal of the button of bone the further procedure must be determined by the condition of the parts. It may be possible now with Nélaton's probe or the telephonic instrument of Girdner to follow the bullet in its reflected path, locate, and remove it. That too much interference is not necessary, and that it pays to stop after reasonable effort, are illustrated by a case in the practice of my colleague, Dr. Parmenter.[1]

Other foreign bodies which are occasionally driven into the brain besides particles of bone are hair, pieces of hat or clothing, splinters of wood, or other substances which it is not necessary to catalogue. Be they what they may, there is the greatest urgency for their complete removal, since one may be quite sure that with them infectious germs

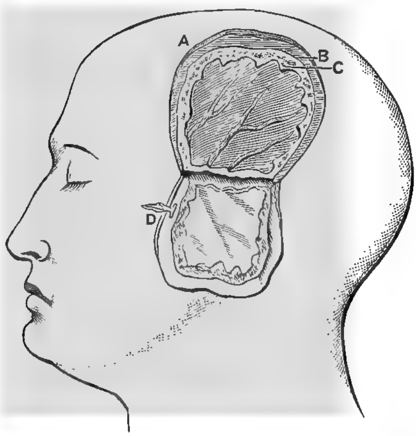
[1] Dr. Parmenter has furnished notes of the case of a man of fifty-four with gunshot wound of the external angular process on the right side, the orbit being shattered, the bullet passing upward across the frontal lobes. The skull was trephined at the point of entrance. A probe, passed along the course of the ball, impinged on the inner table of the skull on the left side, about two and a half inches above the middle of the left superciliary ridge. Here the skull was again trephined, and on the under surface of the button of bone was seen the mark of the ball, which had struck here and glanced downward, tearing a second hole in the dura. Further attempts to locate the ball seemed futile. The bullet-track was drained by a tube from one opening to the other. Seventy hours later the man's temperature rose, and for five days his condition was variable, but with constant pyrexia. On the eighth day he was trephined again, just above the base-line of the skull, one inch in front of the ear, to discover, if possible, the ball or any abscess about it. After opening the dura a slender knife was passed inward and upward to the depth of two inches. This puncture was followed by copious flow of cerebro-spinal fluid, showing that the lateral ventricle had been opened. Repeated exploration in every direction, made with the needle, failed to discover the ball. Within a few hours his condition improved in every respect. A day or two later he became conscious and rational, and after about five weeks was removed to the jail. Here, again, after a few days, he was seized with convulsions and was once more removed to the hospital. The convulsions did not recur, however, and after a few days he was again transferred to the jail, tried, and sentenced to five years in the penitentiary, where he is now serving his sentence.

have been also carried in, and that subsequent brain-abscesses or purulent meningitis may be caused if the source of infection be not completely removed and the cavity drained at least for a day or two.

Operations for epilepsy and the results of cerebral irritation have for the most part found sufficient description under their appropriate headings. The directions may be briefly summed up in the advice to detect the cause with the least possible amount of surface disturbance, to remove it with the least possible amount of deep injury, but to remove it absolutely and thoroughly, and then to atone for such removal, so far as one can, by accurate closure with the use of gold-foil, to obviate as far as one may the untoward effects of adhesion or of anchoring the brain to the overlying dura and skull.

Operations for the removal of tumors must also be based upon general principles, many of which have been already enunciated. The tumor having been localized, one may be quite sure that a reasonably extensive opening at least will be required. This would probably be made by means of some of the osteoplastic methods considered below. Should it be necessary to remove a large area of dura, it would probably be well to substitute with gold-foil or some other material, in order that cortical adhesions may be, so far as possible, prevented. When extensive removal of tissue has been necessitated, the wound must be tamponed for a reasonable time in order that brain-pressure may be equalized, as has already been insisted upon under the heading of Brain-tumors. The checking of hemorrhage, the dressing of the wound, provisions for drainage, etc. have been treated of as fully as space will allow under that heading.

FIG. 451.

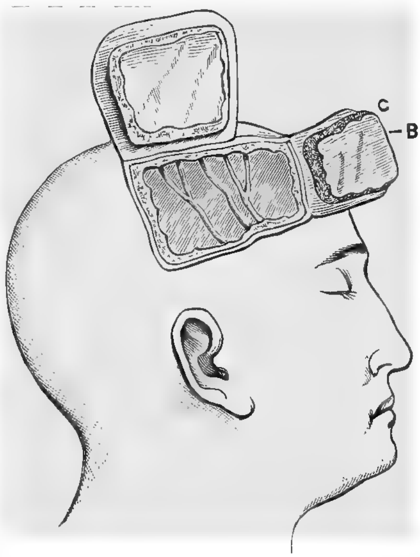


Osteoplastic resection after Wagner (Chipault).

Of late years *autoplastic methods* have been so far improved on as to include a certain *plastic surgery of the cranium* itself. As a consequence we have now a variety of so-called "osteoplastic" methods of opening the cranium which have added very materially to the art of the surgeon in cases of a character demanding intracranial operation. This has been due to the combined efforts of a number of surgeons in various parts of the world, and it is consequently difficult to give any one man the credit for this great improvement, though probably Wagner's name is more prominent in this connection than that of any other individual. In a general way these consist in the more or less complete detachment of a section of the cranial vault, with the formation of a window, as it were, in the cranium, which is afterward closed by the replacement of the piece of bone, which has not been completely severed from its vascular supply. In very young subjects the bone is so elastic as to permit it to be sprung to a considerable extent, permitting a variety of manipulation beneath. In the skulls of adults or adolescents it is necessary usually to

cut away a section of bone after incising the scalp in such a way as to make a rudely horseshoe-shaped opening, the peninsula of bone left at the base of this osseous flap being broken through with forceps or divided with saw and chisel. All of these measures are carried out upon the principle that the soft parts are to be detached from the bone-flap to only the slightest necessary extent, the subsequent nutrition of the broken bone being supplied through vascular connections with these soft overlying tissues. There is scarcely any reasonable limit to the extent to which this idea may not be carried out in practice, certain fundamental principles, however, being observed. The first of these is to provide for a proper blood-supply to the bone. Consequently, the bony peninsula is made on the lower aspect of the flap whenever possible, the larger part of the incision being carried up more or less near to the middle line. Again, the width of the basal portion of the bone-section is preserved as great as safely can be, especially when the periosteal bridge is left undivided, as it is usually intended to be. The shape of the flap, both in the scalp and the bone, may be quadrilateral or omega-like, as may best suit the requirements of the case; and when it is desirable to resect an extensive portion these flaps may be made in two pieces, as suggested by Wagner and shown in the accompanying cut. Toison has even devised a very thin ribbon-like saw which may be passed in at one trephine opening and out through another, and used as a band or chain saw for cutting out through the bone. This of course presupposes that a small trephine has been used at two or more points, making openings through which it can be passed. Could one only ensure that the dura thereby were not injured, it would be in many respects a desirable method of opening the skull.

FIG. 452.

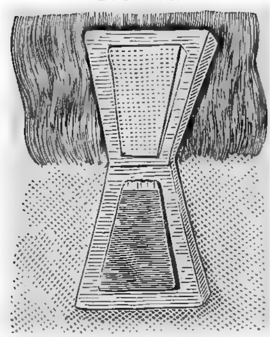


Double osteoplastic resection, as suggested by Wagner (Chipault).

The method, however, must be in large measure based upon the purpose for which the opening is made. When for the removal of tumor it is not nearly so desirable to excise a wide margin of bone in order to prevent speedy ossification. In tumor cases, therefore, as in operations for epilepsy, etc., we probably desire the speediest reunion, and it will be at least theoretically wise to take away as little bone as is possible. Here, then, such a saw may be used, or with the chisel a narrow groove can be cut away, so that after thinning it the bone-cutting forceps can be used to advantage. In cases where the skull is opened for the purpose of permitting expansion of the cranial contents, as in microcephalus, arrested development, etc., we aim deliberately to take away a wide section of bone; and in this case, after making the preliminary trephine

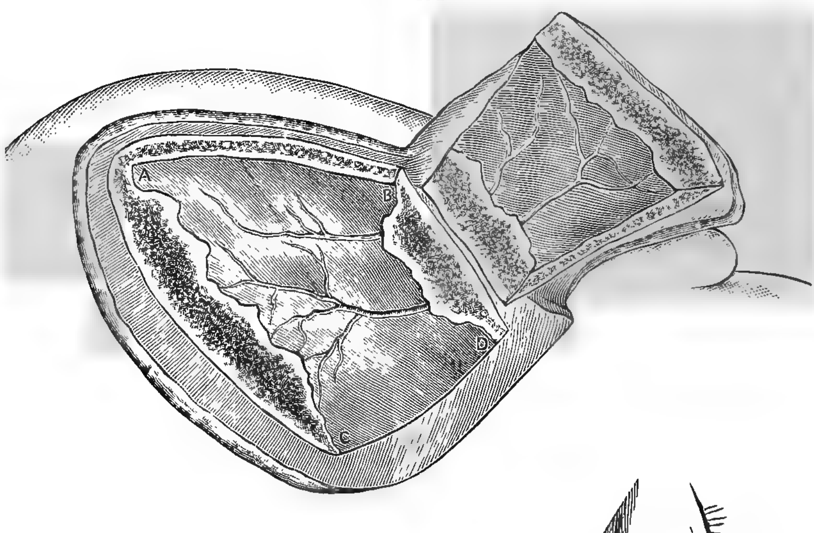
opening at one or two points, the bone is bitten away to the full width of the rongeur forceps. At other places in this article the objection has been raised to the prolonged use of hammer and chisel, by which undoubtedly shock is increased. This is done in spite of the fact that many Continental surgeons advise the use of the chisel. In the hands of American or English surgeons, however, its prolonged use is almost always deprecated. Nevertheless, by the skilful use of the chisel it may be possible to so bevel the margins of the bone while cutting them away as to form a trap-door of such character that its surface cannot be depressed below the margin of the surrounding bone by any possible pressure. This is, in theory at least, an advantage. In practice, however, experience has taught that it is scarcely necessary to observe these theoretical niceties, and that when it is necessary to make a trap-door operation it can be done with but

FIG. 453.



Temporary resection (after Chalot).

FIG. 454.



Chipault's temporary osteoplastic resection; bone-edges bevelled.

little regard to the subsequent effects of pressure, since reunion and firm cicatrization usually occur as rapidly as they could be desired. The illustrations of this subject will sufficiently describe the operation and obviate

the necessity for much of verbal description at this point. I would wish, however, to urge that the scalp incision and that in the bone be not made in the same lines, but that they be at least half an inch apart; also to impress the general utility of not endeavoring to get immediate reunion throughout such a wound, but of inserting iodoform gauze, which I, for my own part, prefer to saturate with a thoroughly sterilized ointment containing some antiseptic which shall be laid in along the line of section of bone, the scalp being closed over it by secondary sutures, the gauze to be allowed to remain for about four days, after which the secondary sutures are untied, the packing removed, and the wound then snugly closed. I have done this in many instances, and have never regretted it, while in some cases where I have tried for more speedy closure I have been disappointed.

The practice of replacing the buttons of bone removed after trephining has not found general favor, and is now employed by but few, since results have not really justified such attempts. The following method of opening the skull has been recently suggested by Cotterill,[1] and has much about it which recommends it for general adoption. Epitomized, the various steps of the operation are as follows:

1. The base of the proposed flap should be a part of the scalp carrying large vessels.
2. Make two small V-shaped incisions, corresponding to the lower ends of a horseshoe flap, their angles looking toward each other. Carry these down to the bone, and strip off the pericranium over a surface half an inch in diameter.
3. With a small trephine remove a disk of bone at each of these points.
4. Pass a periosteum-scraper from one of these to the other between the pericranium and the skull.
5. With a fine saw passed along this channel divide the neck of the bone between the two openings, cutting only to the level of the inner table; which may be easily done, since the difference between sawing the diploë and sawing the inner table is quite perceptible. If necessary, pass a curved director to protect the dura. By doing this first there is less disturbance of relation of flap and bone.
6. Complete the horseshoe incision, making it of any desired size. Divide the pericranium all around this line of incision, not dislodging the soft parts.
7. Use a semicircular saw around this line, applying it obliquely from without inward at the expense of the inner table, so that when the flap is restored it shall not sink below the level of the skull. Although not absolutely necessary, this will be easier if two small disks of bone be removed at the upper angles of the flap, doing which does not materially delay the operation.
8. Lift up the flap of bone with four elevators, when the inner table will be found to crack across at the neck with absolute precision. In doing this the dura is exposed, and any proper procedure may be further carried out.

This form of operation is not applicable to all cases, but principally to those where large openings must be made for diagnosis or removal of

[1] *Edinburgh Med. Journ.*, Jan., 1895.

tumors. It may also be useful in dealing with hemorrhage. It is neither tedious nor difficult.

In considering these osteoplastic methods it is of course taken for granted that they are done for the purpose of exposing some lesion which has already been considered, and that further directions for specific procedures have been given either above or in some other portion of this article when dealing with the same.

Finally, osteoplastic methods are occasionally resorted to for the purpose of covering traumatic defects in the skull. They have indeed been divided into homoplastic, heteroplastic, and autoplastic. The first is that least often resorted to. Nevertheless, the experiments of Merwen [1] and of Ollier,[2] as well as of others, show that it is possible in selected instances to accomplish a great deal by this method. For this purpose pieces of bone taken after osteotomy or after fresh amputation have been used, while Poncet once resorted to the bone removed from a new-born infant dead of asphyxia. The heteroplastic method has been especially resorted to since the recommendations of Koenig. Autoplastic methods include the use of decalcified bone, celluloid, and other material.[3]

Decalcified bone has been recommended by Senn and by Kemmul:[4] Le Dentu[5] and Keen[6] have reported success with this method. Hinterstoisser[7] has also had encouraging success with celluloid. Very thin plates of this material are made, and then so cut in shape as to be neatly fitted in the margin of the bony opening and held there. In each case we can insert a plate, enclose it at once, and have primary healing. Heteroplastic attempts have also been made with bones of living animals, as, for instance, by Jaksch,[8] who used pieces of goose-bones, and Keen, who tried small pieces from the skull of a sheep. Macewen has used dogs for this purpose, and Gerstein has employed rabbit-bone. Kehr of Halberstadt and Koenig have also suggested methods of raising a portion of the external table with its overlying periosteum, a periosteal bridge

[1] *Proceedings Royal Soc.*, 1831, No. 213. [2] Poncet, *Congrès français de Chir.*, 1886.

[3] The covering of recent or old skull-defects has been, for several centuries, a debated subject among surgeons. In 1820, Walther replaced a resected portion of the skull, and got partial healing of the replaced bone. Later a number of surgeons experimented with the subject, and in 1868, J. Wolf succeeded pretty uniformly with animals in reimplanting bone. Macewen, Weir, and others later began to recommend the restoration of bone in small fragments, which were sown, as it were, over the sutured dura. Then began other transplantation experiments, while the investigations of Adamkiewicz ("Ueber knochen Transplantationen," *Bericht. der Acad. der Wissensch.*, Wien, 1888) demonstrated the possibility of healing the reimplanted bone; Guérin (*Bull. de l'Acad. de Méd.*, 1888, No. 44) transplanted bone from one living animal to another, usually with success; and, finally, Seydel (*Centralblat. f. Chir.*, 1889, No. xii.) transplanted bone from the tibia of a patient to the skull, and replaced that which had been lost as the result of a compound fracture. Since these experiments have been made others have been tried with various other materials, living and dead—such as decalcified bone, ivory, aluminum, celluloid, etc.—to cover in defects in the bone, and, though in a few instances such efforts have been followed by success, they have for the most part failed. Eiselsberg (*Inter. klin. Rundschau*, 1891, No. xxiv.) and Fränkel (*Billroth's Festsch.*, 1892) have been the most successful in this regard. Probably the most reliable material for general use for this purpose is celluloid. Beck has reported an apparent success with this—namely, a proper encapsulation of the plate, but with spontaneous extrusion of the same three months later.

From all of which it would appear that the osteoplastic method of closing defects in the cranial bones is the most successful of all which can be tried.

[4] *Deut. med. Woch.*, 1891, No. 11. [5] *Gaz. des Hôpitaux*, 1891.

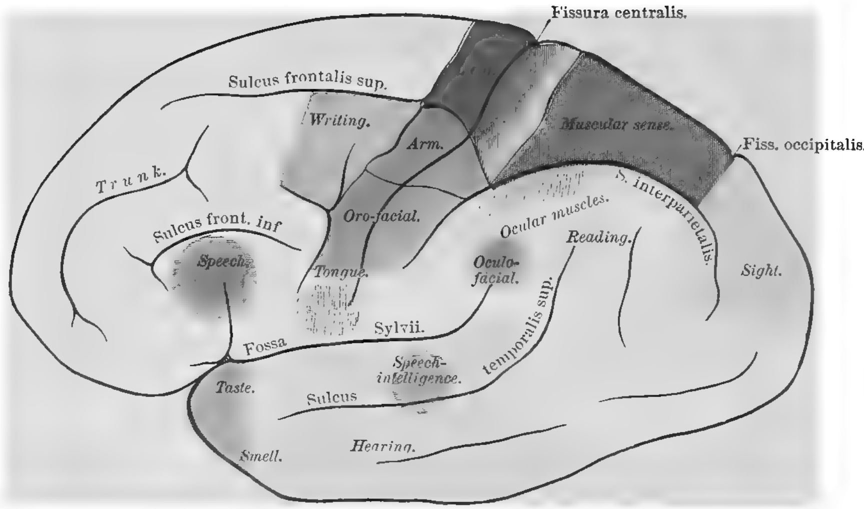
[6] *Am. Journ. Med. Sci.*, Sept., 1891.

[7] *Wiener klin. Woch.*, 1890, No. 43, and 1891, No. 16.

[8] *Wiener med. Woch.*, 1889, No. 38.

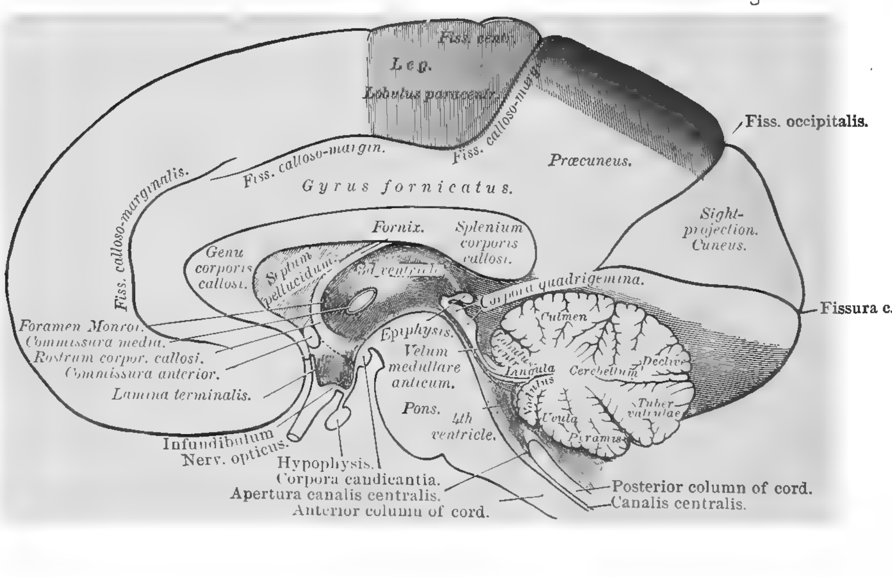
PLATE IX.

Fig. 1



Topographical anatomy of cortex. Localization of functions. (Ziehen.)

Fig. 2.



Topographical anatomy of inner surface of right hemisphere. Localization of functions. (Ziehen.)

being made, and transferring this to cover the defect which it is intended to protect. It will frequently be enough if, with the periosteum, a thin layer from the external table be raised by the chisel.[1]

There remains only to indicate a suitable method for determining the location of the various centres of the brain, since surgical procedures must be guided by accurate anatomical data. The areas which most concern the surgeon are mainly those which cluster about the fissure of Rolando, and the proper determination of its locality is to the surgeon what the long base-line is to the geodetic surveyor.[2] The reader's attention is called to the illustration from Macewen on page 708, where are outlined certain topographical marks, as well as certain points in the regional anatomy of the skull, which have been carefully described by Broca. The principal landmarks of importance are the *glabella*, at the root of the nose; the external occipital protuberance, known as the *inion;* the *bregma*, halfway between these; the external angle of the orbit; the tip of the mastoid; and the lower border of the alveolar process of the upper jaw. The fissure of Rolando has its upper end about 5 cm. back of the bregma, though not quite extending to the middle line. Its lower end lies about a half a centimetre behind the auriculo-bregmatic line, a little above an imaginary horizontal line parallel to the alveolo-condyloid line. Thus the lower end of the fissure of Rolando will be found about 6 cm. above, and a little behind the external auditory canal—*i. e.* about $2\frac{1}{2}$ cm. behind the bifurcation of the fissure of Sylvius. In the *Lancet* of March 3, 1888, p. 408, Hare of Edinburgh showed that the distance of the upper end of the fissure is about 55 per cent. of the total distance from the glabella to the inion, and that the angle which it forms with the median line is about 67°. Horsley has shown that under certain conditions these distances and angles vary a little, but not sufficiently so to affect the general rules governing operations. In accordance with Hare's measurements and Chiene's suggestions, Wilson devised a simple instrument, known as the "cyrtometer," consisting of a T-shaped flexible metal device whose lower border is secured around the head by a tape in a position nearly corresponding to Reid's base-line, while the antero-posterior arm extends from the glabella to the inion, and is marked with scales from A to Q and a to q. The distance from the glabella to a is 55 per cent. of the distance to A, etc. A smaller arm sliding along this branch is set at an angle of 67°, and is placed at the small letter corresponding to the large one which marks the position of the inion when the instrument is *in sitû*. It will then closely or exactly overlie the fissure of Rolando, whose location may be marked with the dermograph or scratched upon the scalp. In very young children this fissure, however, is much more oblique, the angle being reduced even to 52°, and is located farther forward, because the frontal lobes are relatively less developed at this early age.

How important it is to the surgeon to locate this fissure will be realized by a glance at the illustrations (Plate IX., Figs. 1 and 2), since

[1] *Vide* also Göz, "Ueber ausgedehnte Resection d. Schädelknochen," *Beiträge zur klin. Chirurgie*, iii. 95; Mellinghoff, "Zur temporären Resektion des Schädeldaches," *ibid.*, vii. 637; Reverdin, "Abreissungen d. Kopfhaut durch Transplantation geheillt," *Deutsche Zeitschft. f. Chir.*, vi. 418.

[2] See Park, "Surgery of the Brain," *N. Y. Med. Journ.*, Nov. 3, 1888.

around it closely cluster the most important centres and fissures of the cerebrum; and it is enough for almost all surgical purposes to locate this, while for the most part disregarding the other fissures.

A still more simple method of rudely ascertaining its location has been suggested by Prof. Chiene, who folds a square piece of paper once, thus making a triangle whose lesser angles are made 45° each. One half is then folded back on itself, so that its angle is reduced to $22\frac{1}{2}$°. This being cut away or left folded, the balance of the paper is unfolded, forming then a trapezium, one of whose angles is 45° plus $22\frac{1}{2}$°—*i. e.* $67\frac{1}{2}$°—which is accurate enough for all practical purposes. One side of this being applied to the middle line of the head, the position of the Rolandic fissure can be easily ascertained, and, its length being $3\frac{3}{8}$ inches, the surgeon can easily ascertain what point on his own forefinger corresponds to this in length, and thus can make out its lower limit. It is then only necessary to make out the location of the upper end, which in this method is estimated as half an inch back of the middle of the line from the glabella to the inion—in other words, rudely, 55 per cent. of said distance. Numerous other methods have been suggested, and in the works of Chipault and of Gallez some twenty or twenty-five plans find illustration. These are altogether too many in number and are absolutely unnecessary. The two methods suggested above are those which find most favor in this country, and are sufficient for the purpose, we believe, particularly so since we now know with what impunity a little more bone can be cut away with rongeur forceps should the trephine not have been placed accurately over the area which we seek. Moreover, the exact location of these areas is not to be made out so much by topography as by electrical excitation, the gentle current from a single dry-cell battery being passed through an induction coil and giving an induced current of sufficient intensity for all these purposes. With the electrode devised by Keen, or its equivalent, the final localization must be made, at least when we are working in cases of epilepsy or those of kindred character in which no visible lesions are made out or no visible tumor requires removal. On the other hand, when we are attacking visible manifestations of disease they are to be removed without reference to areas involved or topographical lines.

The fissure of Sylvius is occasionally sought for, or at least its location desired. Suffice it to say here that its bifurcation corresponds to the point one and one-quarter inches behind and one-quarter inch above the level of the external angular process of the frontal bone, its point of division being just beneath the *pterion*—that is, the H-shaped junction of the parietal, the great wing of the sphenoid, the frontal and squamous bones. The anterior branch runs upward and forward, almost beneath the line of the sphenoido-squamous suture. It is the anterior boundary of the so-called "motor" region, the posterior branch bounding the same area inferiorly.

It would seem as though the practical relations of cranial topography to surgery may be summed up in these words: The principal areas whose location is definitely known, and which may be sought for by the surgeon because of irritative lesions, are those near enough to the fissure of Rolando to be made out according to rules already given. On the other hand, for more vague or uncertain lesions, whose location is

conjectural, definite rules cannot be laid down, and the surgeon must either be guided by general experience or else must make an opening at that location to which most of the signs point, and must make this opening large enough, or must explore far enough in various directions from it, to obtain the knowledge which he seeks or carry out the measures of extirpation which he desires; and these operations would be better practised by means of some of the osteoplastic resections than by means of a single trephine opening, whose exact location must be determined rather by chance than by accurate knowledge.

For more exact descriptions and detailed directions the reader is referred to the monographs of Roberts, *Operative Surgery of the Human Brain;* Seydel, *Antiseptik und Trepanation;* Horne, *Trephining in its Ancient and Modern Aspect;* Lucas-Championnière, *Étude historique et clinique sur la Trépanation du Crâne; La Trépanation guidée par les Localisations cérébrales;* Gallez, *La Trépanation du Crâne;* the two monographs of Bergmann, *Deutsche Chirurgie,* Lieferung 31, *Chir. Behandlung von Gehirnkrankheiten;* Chipault, *Chirurgie opératoire du Système nerveux;* Fraser, *Guide to Operations on the Brain;* and the various journal articles of Horsley, Keen, Köhler ("Ueber die Methoden die Lage, etc. der Hirnwindungen zu bestimmen," *Deutsche Zeitschft. f. Chirurgie,* xxxii, 567), the writer (Park, "Surgery of the Brain," etc., *N. Y. Med. Journ.,* Nov. 3–17, 1888), etc.

THE SURGERY OF THE SPINE.

BY W. W. KEEN, M. D., LL.D.

BEFORE considering the surgery of the spine it is well to recall briefly the anatomy of the parts. The spine consists of twenty-six bones, the last two of which, the sacrum and coccyx, are made up of several vertebræ fused together. The bodies of the vertebræ form a column for the support of the head and upper extremities (Fig. 455). A bony arch extends posteriorly from the body of each vertebra, the whole series forming a canal which affords protection to the spinal cord itself. The curves of the spine are chiefly caused by inequalities in the vertical thickness of the bodies of the vertebræ. The articular processes of the vertebræ are arranged in such a manner as to prevent dislocations, either by their position, as in the lumbar region, or of their obliquity in the cervical, while in the dorsal region the ribs form additional buttresses to prevent such displacement.

The muscles of the spine are very large and thick, and fill up the concavity between the spinous and the transverse processes. These muscles are largely made up of separate slips, partly muscular and partly tendinous. They pass from one vertebra to another, and hence in an operation upon the spine these muscles are apt to be frayed out, so to speak, in cleaning the bones to get a clean field of operation, and this frayed condition favors local necrosis and should be avoided as much as possible. Hence the knife rather than dull scraping instruments should be used to expose the laminæ.

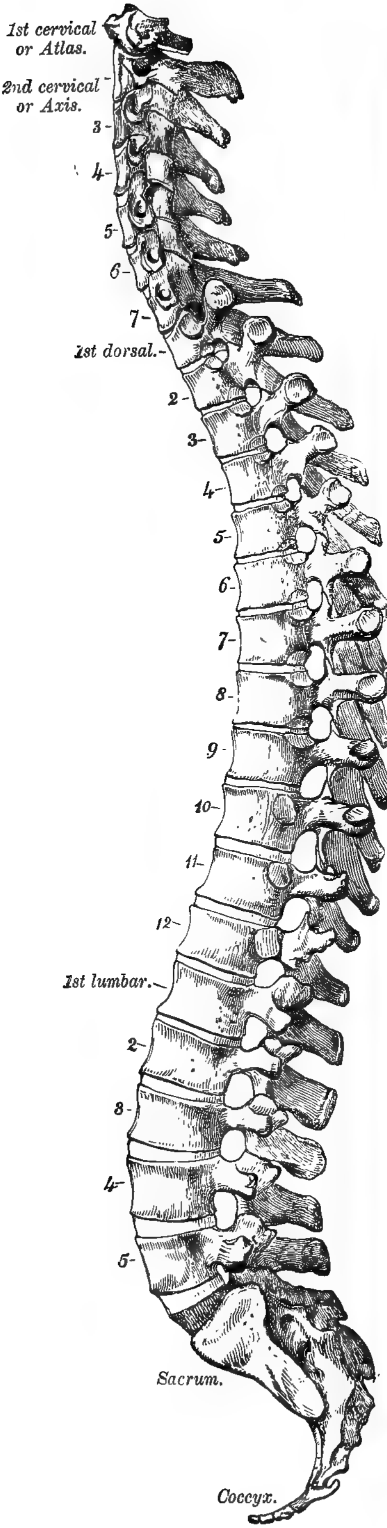
In the spinal canal hangs the spinal cord, covered by its membranes and still further protected by the cerebro-spinal fluid between the cord and its membranes. The cord is steadied in the tube formed by its membranes not only by the fluid, but also by the ligamentum denticulatum and by the nerve-roots as they pass through the intervertebral foramina.

It is well known that the spinal nerve-roots do not emerge from the spinal canal through the intervertebral foramina directly opposite their apparent origin from the cord. After leaving the cord they run downward in the spinal canal to a greater or less extent, and make their exit from the canal at varying distances below their origin. For careful modern clinical observation in nervous diseases and injuries it is extremely desirable to have as nearly as possible an exact knowledge of the segment of the cord from which each nerve originates and the relation of the segment of the cord to the spinous processes.

Fig. 456, from Reid,[1] shows the relations of the cord, the nerve-roots, and their foramina of exit very accurately. Inspection of this figure

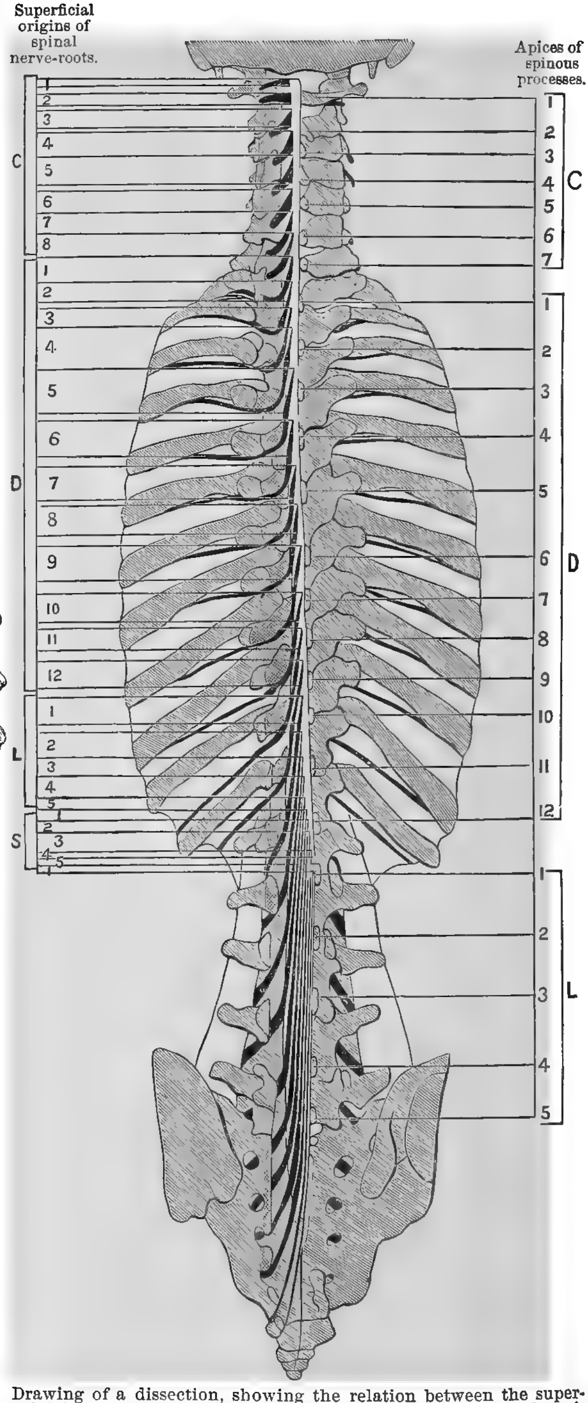
[1] *Journ. Anat. and Phys.*, 1888–89, xxiii. 341.

Fig. 455.



The spinal column, side view (Gray).

Fig. 456.



Drawing of a dissection, showing the relation between the superficial origins of the posterior roots of the spinal nerves and the spinous processes of the vertebræ (R. W. Reid).

shows that, for instance, the eighth cervical nerve takes its origin from the space between the spinous processes of the fifth and sixth cervical vertebræ, and makes its exit below the spine of the seventh cervical. Again, the eighth dorsal nerve originates below the level of the fifth dorsal spine, and makes its exit below the sixth dorsal spine, while in the cauda equina the nerve-roots originating in the segment between the twelfth dorsal and first lumbar run all the way down to various points of exit as far as the coccyx. A careful study of this figure will afford much information in not a few cases of spinal disease or injury. Chipault[1] has also given an excellent description of these relations. (For the relation between the spinal segments, the nerves originating from them, and the areas of skin and the muscles supplied by each nerve see the table on p. 815.)

Congenital Deformities of the Spine.

Congenital deformities consist principally of three: first, attached fœtus; secondly, congenital sacro-coccygeal tumors; and, thirdly, spina bifida.

Attached Fœtus.—The most frequent form of this condition is that of a third leg attached in the sacral region. It consists practically of two legs blended into one, usually dwarfed and otherwise deformed. Sometimes, however, it is more or less normal in appearance. Those who desire fuller information will find excellent illustrations of the principal varieties in Braune's classical work.[2]

The **treatment** of such a deformity is amputation, provided its relation to the bones of the pelvis is such as to allow of its removal. This should be carefully examined before any operation is undertaken.

Congenital Sacro-coccygeal Tumors.—Such tumors are much more frequently found in girls than boys, Molk noting, in 58 cases, 44 in girls to 14 in boys. Sometimes such tumors are really examples of spina bifida, which is described below. The latter lie posterior to the coccyx and are connected with the cavity of the spinal canal. A true sacro-coccygeal tumor, as has been described by Sutton,[3] lies in front of the coccyx instead of behind it (Fig. 457), and is an excellent illustration of a tumor arising in connection with an obsolete fœtal canal. In the early

Fig. 457.

Congenital cystic sacral tumor lying anterior to the coccyx: *S. C.*, spinal cord; *L. A.*, levator ani; *G.*, gut; *In.*, innominate bone (modified from Braune by J. Bland Sutton).

[1] *Rapports des apophyses épineuses avec la moelle, les racines médullaires, et les méninges*, Paris, 1894.

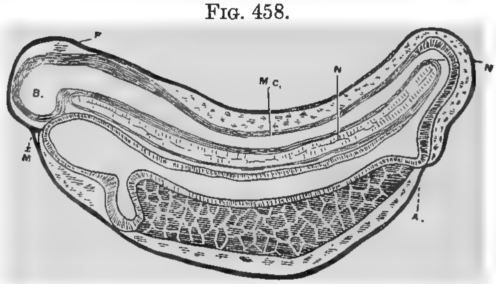
[2] *Die Doppelbildungen und angeboren Geschwulste der Kreuzbeingegend*, Leipzig, 1862.

[3] *General Pathology*, pp. 330–339.

development of the fœtus, as was first pointed out in 1871 by Kowalevsky,[1] the central canal of the spinal cord is continued around from the back to the front of the coccyx, where it becomes continuous with the intestine in the part now known as the post-anal gut; that is to say, the anus is not the true end of the bowel, which extends in fœtal life beyond—*i. e.* posterior to—the anus, and is continuous with the central canal of the spinal cord. This canal, connecting the bowel with the central canal of the cord, is known as the *neurenteric passage or canal* (Fig. 458). This passage, or post-anal gut, has been found in very many animals, up to and including man, and gives rise occasionally to congenital tumors, especially by dilatation. Hence these tumors are not uncommonly cystic. In other cases, where the walls develop rather than the canal itself, they are fatty in character. Such tumors were formerly supposed to arise from Luschka's gland, but there seems no reason now to doubt their relation to the post-anal gut.

These tumors are of course always congenital, sometimes sessile, or

FIG. 458.



Longitudinal section of an embryo of *Bombinator igneus*: *B.*, brain; *P.*, pineal gland; *M. C.*, spinal canal; *N.*, notochord; *M.*, mouth; *L.*, liver; *A.*, anus; *M. C.*, mesenteric canal (after Goette by Sutton).

even almost entirely intrapelvic, as in the case which I operated on and reported.[2] At other times they are pedunculated. They are apt to be mistaken for fatty tumors, especially if they attain considerable size. They vary from the size of a walnut to that of a child's head, or even larger. If cystic—as they often, in fact usually, are—they will be in parts elastic or even fluctuating, in other parts much more firm and solid. Occasionally, as in my own case above alluded to, the coccyx will be pushed far backward, so much as to cause great inconvenience when the patient sits down. In other cases the anus and genitals may be pushed much forward. The relations of the tumor to the rectum should of course be most carefully studied before any operation is undertaken. If they are operated on, entire removal should be the rule, the greatest care being taken to see that no injury is done to the bowel. In my own case there was, curiously enough, associated with the tumor also a dermoid.

Spina Bifida.—By far the commonest form of congenital anomaly of the spine is that known as spina bifida. Demme has recorded 57 cases out of 36,148 births, and Chaussier 22 cases in 22,293 births. As it is a defect of development, the same cause which produces this defect is apt to produce defects elsewhere in the development of the ovum, and hence

[1] *Archiv f. Mikr. Anaton.*, Bd. vii. S. 114. [2] *International Clinics*, October, 1891.

it is very apt to be associated with hare-lip, cleft palate, hydrocephalus, paralysis, club-foot, and imperfect mental development (Fig. 459). Precisely what is the cause for this or any other irregularity of development

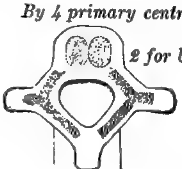
FIG. 459.

Spina bifida with club-foot and strabismus (Lloyd).

is unknown. In the embryo the vertebral canal is formed by a furrow in the mesoblast, the sides uniting to form the spinal laminæ, which coalesce at the spinous processes. The ossification of the bony rings which enclose the spinal cord is, as is well known, by four principal centres (Fig. 460), two for the body of the vertebra, and one for each lamina, the two laminæ uniting in the median line at the spinous process. If for any reason the laminæ do not unite in the middle line, an opening or defect in the bony structure results, through which more or less of the membranes or of the cord itself may protrude. This defect, though it may be limited to a single arch, usually extends to the arches of several vertebræ.

FIG. 460.

By 4 primary centres.



Development of a vertebra (Gray).

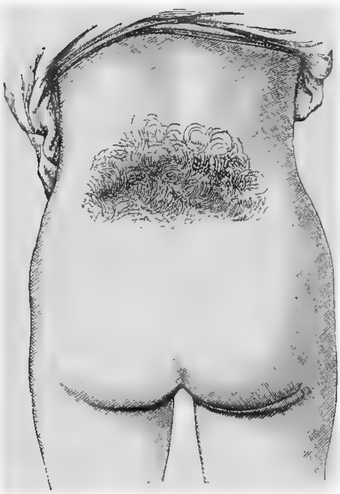
Very rarely, by a failure of the two centres for the body to unite, an anterior spina bifida may result.

The form of malformation known as *spina bifida occulta,* in fact, is

one in which the defect in the bone exists without protrusion of the membranes or cord, and hence, as no tumor is formed, it is apt often to be overlooked. What, however, will make us suspect its existence is a peculiar patch of well-developed hair over the site of such a spina bifida occulta (Fig. 461). (On pp. 796, 797 a case is recorded of a successful operation on such a malformation.)

In case there is a defect in the posterior arches of the spine, there may be a projection through the opening—first, of the membranes alone, the cord remaining in its proper place; secondly, the membranes and cord both may project through the opening; and, thirdly, not only may the membranes and cord project, but the central canal of the cord may be greatly distended with the fluid, reducing the cord itself to a thin layer immediately inside the membranes. These three varieties correspond exactly to similar malformations in the skull and brain. Accordingly, the classification of the Committee of the Clinical Society of London[1] finds its anatomical reason. Where the membranes alone protrude through the opening and are distended with fluid the tumor is known as a *meningocele;* secondly, if the cord is attached to the posterior part of the sac and protrudes with it through the opening, we have a *meningo-myelocele;* and thirdly, if cord and membranes protrude and the central canal of the spinal cord is distended by the cerebro-spinal fluid (hydrorrhachis interna), we have then the form of tumor known as *syringomyelia.* Of the three varieties, the second is, unfortunately, by far the most common, the entire cord—or, especially in the lower part, the nerves of the cauda equina—being contained in the tumor and attached to its posterior surface.

FIG. 461.



Hair-field on the loin overlying a spina bifida occulta (after Virchow by Sutton).

The fluid, which has been repeatedly examined, is identical with the cerebro-spinal fluid.

The reddened, enlarged tumor lies in the vast majority of cases in the lumbar or sacral region. Of 402 tumors collected from various sources, I find 329 in the lumbo-sacral region. The situation of the tumor is always in the median line or very nearly median. Its size varies from a mere bulging of small moment to a tumor the size of a fist or even larger. The tumors are sometimes sessile, sometimes pedunculated. Occasionally the fluid in them can be pressed back into the spinal canal and the bony opening can be felt, but more often the dense fatty tissue around the margins, as well as the tenseness of the sac, will prevent our feeling the bony opening. Attempts at reducing the fluid within the spinal canal are not without danger, as the increased spinal, and even

[1] *Trans. Clin. Soc. London,* xviii. 339.

intracranial, pressure is very apt to produce convulsions. If hydrocephalus exists, not uncommonly pressure upon the spina bifida will be appreciated by touch in the hydrocephalic head, or *vice versâ*. When the child lies down, and especially if the hips are higher than the head, the fluid drains gradually away from the tumor, which becomes less tense; when the child is placed erect, the tumor will become more tense. All expiratory efforts, such as crying, markedly increase the tension of the sac. The skin over the tumor is sometimes very thick, tense, and brawny. At other times it is excessively thin, and even translucent, so that if the tumor is examined through a cylinder of paper, a light being held upon the opposite side, it will be as translucent as a hydrocele or even more so.

Diagnosis.—Given a congenital tumor in the median line, especially if it be in the lumbo-sacral region, distended with fluid, varying in tension by posture or expiratory efforts, and possibly accompanied with other deformities in the body, and the diagnosis of spina bifida is well assured, even though the defect in the bone cannot be discovered.

The diagnosis of the variety is, however, by no means so easy, and yet is very important in deciding the question of treatment. Where there is paralysis with atrophy of the lower extremities or loss of control of the sphincter muscles, it is fairly certain that we have to deal with a meningo-myelocele. So, too, if the post-anal dimple is found, an umbilicus-like dimple marking probably the termination of the spinal cord and its attachment to the skin, it is almost certain that the cord lies in the tumor. If the covering is translucent, we can sometimes see the nerves traversing the tumor or feel the thickened more resistant sac-wall where they are adherent, or rarely can determine probably their absence.

Prognosis.—The vast majority of children born with such a defect fortunately die very early. The tumor usually gradually, but sometimes rapidly, increases in size, the skin ulcerates, and finally the sac bursts, not only evacuating the cerebro-spinal fluid itself—a serious danger when rapidly and continuously lost—but, if death does not take place at once, infection will produce a spinal meningitis which quickly will destroy life. Very rarely such rupture of the sac is followed by spontaneous cure. In some cases in which the opening is small it progressively shrinks, and finally cuts off the tumor from any connection with the spinal canal—the so-called false spina bifida.

Treatment.—In the very large proportion of cases practically no treatment other than a palliative one can be adopted. Before any active steps are taken in the matter of treatment the natural history of the disease in the particular case under consideration should be studied. If possible to avoid it, no operation should be done under two or three months after birth, though Walther[1] operated successfully five hours after birth; but the parts should be protected either with cotton smeared over with vaseline or by a rubber or other moulded splint held in place by a bandage, both protecting it and producing somewhat of pressure if the skin will allow it. Sometimes collodion with or without iodoform may be painted over the sac with a view to shrinking it. In case the skin is excessively thin or the tumor very large, or there be

[1] *Rev. de Chir.*, April, 1892, p. 371.

evidence of extensive or multiple defects of development, especially paralysis of the lower extremities and of the sphincters, no other than this palliative treatment or that by injection is permissible. If at the end of two or three months the patient is improving, we should wait still longer until the improvement has at least come to a standstill. Spontaneous cure may take place, and we should always give Nature—who if a successful surgeon is the best surgeon in these cases—a chance to see what she can do. Failing a cure at this time, or earlier if the patient is getting worse, the question of radical cure is to be decided. Radical cure was formerly sometimes attempted by tapping or puncture, a procedure which no good surgeon now is likely to countenance. Practically, two methods remain—first, the injection of iodine (Morton's fluid); or, secondly, excision.

Injection of Morton's Fluid.—This fluid, introduced by Morton of Glasgow, consists of iodine, gr. x; iodide of potassium, gr. xxx; and glycerin, f℥j. The skin as well as the needle of the syringe having been rendered aseptic, a drachm or two of the contents of the sac are withdrawn, and then half a drachm to a drachm of Morton's fluid is slowly injected, the puncture being sealed with collodion with great care, so as to prevent the escape of the cerebro-spinal fluid. The injection should not be made in the middle line, where the cord may be attached, but well to the side, and if possible through sound skin. In the course of ten days to two weeks, when the slight reaction has subsided, a second treatment may be instituted. In the classical report of the London Clinical Society[1] there were recorded 71 cases treated by Morton's method, of which 35 recovered, 27 died; in 5 there was no improvement, and in 4 there was some improvement—a mortality of 38 per cent. In Morton's own work on *Spina Bifida* (1887) he reports 65 cases treated by various operators, with 55 recoveries and 10 deaths. Powers[2] has added 15 cases collected since the Clinical Society's report, with 4 deaths—a mortality of 26.66 per cent., a much better showing than the Clinical Society's original records. In addition, this method of treatment does not involve an "operation," which is of itself, and very naturally, a great terror to most parents.

Excision.—Unquestionably, however, excision is gaining ground with surgeons. Thus, Powers has tabulated 34 cases, from which he deducts 3, as the cause of death was indefinite, leaving 31 cases, with 24 recoveries, a mortality of 22.58 per cent.—much less than that by Morton's method. Robson[3] has published 20 cases with 16 recoveries, a mortality of 20 per cent.; and Hildebrand[4] has collected 87 cases with 23 deaths, a mortality of 26.4 per cent. Of course if there be other accompanying defects, such as would indicate an involvement of the spinal cord, or if the tumor is very large, the skin thin, or we cannot obtain enough flap for immediate closure, no one would think of excision. Only meningoceles and a few meningo-myeloceles are suitable for operation.

Technique of Excision.—In case the tumor is a simple meningocele, an elliptical incision is made, preserving enough skin on each side to cover in the defect; the sac is then dissected down to its base, the serous membrane at the neck of the sac being sutured with the two serous

[1] *Loc. cit.*
[2] *N. Y. Med. Rec.*, July 16, 1892.
[3] *Lancet*, 1894, ii. 961.
[4] *Deutsch. Zeitsch. f. Chir.*, 1893, xxxvi. 515.

surfaces apposed; or, if very small, the neck of the sac may be ligated and the wound closed in the ordinary way. It is important to prevent the escape of the cerebro-spinal fluid, not so much on account of the immediate danger to life from its escape as to prevent a fistula, which may eventually become infected and be followed by meningitis; and to do this it is advisable that the lines of suture of the sac and of the skin be not opposite each other. How successful the treatment by excision may be in an apparently almost hopeless case is well shown in Robson's third case. She was a girl of sixteen, with a temperature of 102° F., restless, and moaning with intense headache, and with dilated and sluggish pupils. In twenty-six days eighty-five ounces of cerebro-spinal fluid were removed from the sac by eight aspirations, with temporary relief, but finally, as she was evidently failing and must soon die, excision was done, and in thirteen days she was entirely well.

Should the case be one of meningo-myelocele, the nerves will more commonly be found attached to the posterior surface of the sac, from which they should be dissected loose and replaced in the canal, the operation being completed as before. When the nerves are present in the sac, they are more commonly adherent on each side of the middle line, in which line sometimes a furrow exists. Their presence, which is found to be a fact in about 60 or 70 per cent. of the cases, is, as a matter of course, an added danger.

The firmer closure of the opening in the defective spine, however, is the direction in which the chief improvement has taken place from operative interference. Bayer[1] has loosened the muscles on each side of the spine and brought them together in the median line. In 1883, Robson, Jessop, and Hayes of Rochester, N. Y.,[2] sought to close the cleft by using a strip of periosteum from a rabbit, the osteogenetic surface being turned undermost and the piece being sutured to the neighboring periosteum. Perrier[3] refers to a case in which Berger inserted a plate of bone from the scapula of a young rabbit. The case was reported five months after the operation, the cure having persisted, though it was thought likely that the bone had become absorbed.

The most important modification, however, has been introduced by Dollinger, Senenko, and Bobroff of Moscow.[4] Dollinger with bone forceps divided the rudimentary portions of the arches of the fourth and fifth lumbar vertebræ close to their bases, and pushed them close to the middle line, where he secured them by suture. Senenko did a similar operation in a sacral case, chiselling loose from each side a piece of bone two centimetres broad, leaving them, however, in connection with the soft parts at the upper and lower ends. After four months the posterior border of the sacrum showed a continuous bony surface. Bobroff in October, 1891, operated in the following manner: After removing an elliptical portion of the skin covering the sacrum, several nervous cords of the cauda equina and the lower end of the spinal marrow were dissected loose from the sac and replaced in the vertebral canal. The opening was sufficiently large to admit the index finger. Two incisions were next made along the upper border of the ilium, and the gluteus maximus was dissected from the bone. Bobroff then chiselled from the

[1] *Prager med. Wochenschr.*, 1890, p. 49. [2] *Trans. Clin. Soc. of London*, vol. xviii.
[3] *Semaine médicale*, May 18, 1892. [4] *Centralblatt für Chirurgie*, 1892, No. 22, p. 465.

iliac crest a piece of bone three centimetres wide, two centimetres long, and a little less than one centimetre thick. The piece of bone was not chiselled loose, but was turned over on a hinge formed by the erector spinæ muscle, so that the periosteal surface was next to the cord, and the chiselled surface presented posteriorly. The edges of the defect were freshened, two bone sutures were placed in position, the wound being then closed as usual, and the patient laid upon the abdomen. A drainage-tube was used. The cerebro-spinal fluid continued to escape for several days, and then the flow ceased. After two months consolidation of the transplanted bone had taken place and the patient ceased to lie upon the abdomen. Five months after the operation he was in good condition.

This case is not only noteworthy by reason of the method of operating, but also on account of its results. From birth the boy had had incontinence of urine and fæces; after the operation, for three months, first faradism was used, and later the galvanic current, to arouse the sphincters, which then began to act, so that the boy was able to retain the contents of the rectum, not only when lying down, but in walking and running. The sphincter of the bladder, however, only served to retain his urine during the night or when he lay down in the daytime. As soon as he stood up the urine began to escape.

Bobroff proposes, in spina bifida of the dorsal region, to fill the defect from adjacent ribs, chiselling off the outer lamellæ, but leaving them

FIG. 462.

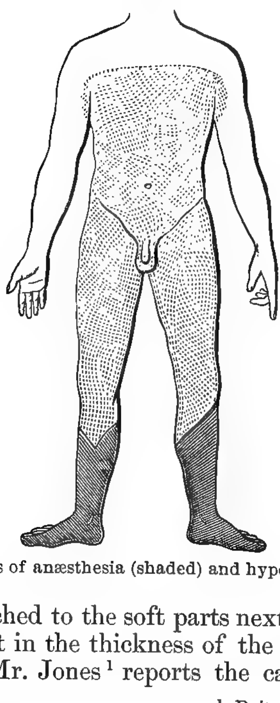
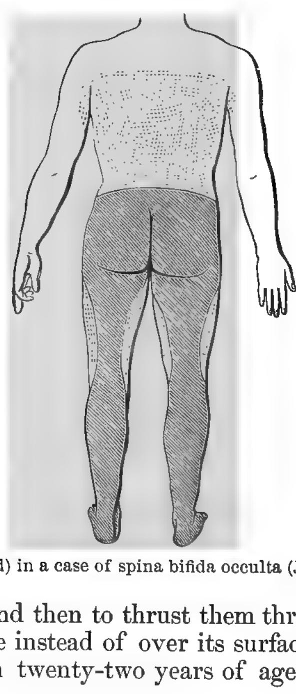


FIG. 463.



Areas of anæsthesia (shaded) and hyperæsthesia (dotted) in a case of spina bifida occulta (Jones).

attached to the soft parts next the spine, and then to thrust them through a slit in the thickness of the erector spinæ instead of over its surface.

Mr. Jones[1] reports the case of a man twenty-two years of age who

[1] *Brit. Med. Journ.*, 1891, i. 173.

had a spina bifida occulta with club-feet. After successful operation on one foot he noticed severe burning pain in the sole, followed by ulceration with discharge of bone, and later perforating ulcers on both feet with great muscular wasting. It was discovered on searching for the cause of the paralytic trouble that there was a spina bifida occulta at the second sacral vertebra. The aperture in the bone was quite perceptible; the skin was puckered and depressed and covered with short hairs. The plantar and patellar reflexes were lost in both legs. The gluteal reflex was very slight, but the cremaster and other higher reflexes were well marked. Figs. 462 and 463 show in the shaded area the region of relative anæsthesia, which, however, was still painful to touch, the dotted areas being those of hyperæsthesia, which gradually faded out as it ascended. The arch of the first sacral vertebra was removed, when a dense adventitious fibrous band about one-half of an inch wide came into view, stretched across the spinal canal and compressing the cauda equina. This band was divided and removed. The cauda equina was deeply grooved by the band. The patient made an almost perfect recovery, and in six months was able to walk without difficulty or pain. Micturition, however, was still slow and occasionally painful.

Contusions and Sprains of the Back; Concussion of the Spinal Cord.

We must recall again the fact that the spine consists of a large number of bones with still more numerous joints—that each bone is bound to its fellows above and below and also to the ribs by numerous ligaments. The motion of the spine consists of flexion forward, backward, to the right and left, and circumduction. No individual joint, excepting that between the head and atlas and that between the atlas and axis, possesses any large amount of motion, but the motion of the entire spinal column is very considerable.

In contusions and sprains of the back we have to consider the injury of the soft parts, and next that of the bones, which may even possibly go so far as a separation of the vertebræ from the intervertebral substances. There may also be sprains or direct injuries of the joints, and, finally, there may be immediate injury of the spinal contents through the vessels, which are sometimes torn, producing hemorrhage, or of the spinal cord itself. Some modern surgeons have been disposed rather to throw doubt on injuries of the cord other than those caused by fracture or dislocation, but there seems to be no doubt from the number of cases recorded—for instance, by Page, Knapp, Dercum, and others—that the cord may be so jarred as to produce minute hemorrhages, followed, as Knapp especially has insisted upon, by chronic sclerosis of the cord itself. In some cases even a very slight accident will be followed by the most serious results; for instance, in a case communicated to me by Dr. Felty of Kansas. A young man, aged twenty-eight, fell from a hammock which was only eighteen inches above the ground. Excruciating pains in the small of the back followed the fall, and he was unable to walk much that day. He applied domestic remedies for the bruise, but the parts remained somewhat lame and locomotion was more or less difficult. Three weeks after the fall numbness was noticed on the inner

side of the calf of the right leg, soon extending to the heel and sole of the foot, with shooting pains and cold sweats in the legs. Paralysis of sensation and motion gradually increased, until in three months after the accident he was unable to void his urine. Six weeks after the accident sensation became impaired in the left leg. He denied that he had ever had syphilis. There was no tubercular history either personal or in his family. The spine was tender over the first and second lumbar vertebræ, and four months after the accident, when Dr. Felty first saw him, there was complete sensory and motor paralysis of the right leg and hip, with pronounced atrophy of the muscles of the right leg. The pain in the left leg was so excruciating that he required from two to four grains of morphine a day to relieve it. Three months after Dr. Felty first saw him, under dry and wet cupping, with strychnine and iodide of potassium up to gr. xc a day, marked improvement followed. Sensation and motion were almost completely restored on the left side, with a fair amount of motion on the right down to the knee. He had also obtained control over his bladder and bowels. His temperature remained normal throughout.

A second, and even more undoubtedly permanent, almost complete, paralysis from an apparently very slight injury of the spine has been recently under my care in the Jefferson College Hospital. A young girl, fourteen years of age, when six years of age tripped and fell on a curbstone, striking the back of her head and the lower part of her back on the stone. She did not lose consciousness, and continued on her way to school. During the afternoon of the same day she vomited, had severe headache, and was unable to return to school in the afternoon. On the second day there was complete paralysis of both legs; the bladder and rectum were not involved. The legs are said also to have been completely anæsthetic up to the level of the injury; sensation gradually was recovered, and at present is normal; all the reflexes in the legs are permanently lost. Her father received from the city very large damages several years ago. The child has never walked since, and presumably never will, though she can move her feet slightly.

Whatever, therefore, may be our view of the propriety of the use of the term "concussion of the cord," there is no doubt that even severe lesions may occur without any external evidence of injury, and be followed by the most serious disability. Thus, Sir William Gull[1] has recorded a case in which death occurred in fifty-five hours, and the post-mortem showed small extravasations of blood in the anterior and posterior cornua and in the posterior columns of the cord. The hemorrhage had produced paralysis both of the upper and the lower extremities, but there was no external evidence of spinal injury. Again, Hulke[2] reports a case precisely resembling this in its symptoms, but with the happier result of a somewhat imperfect recovery. The most noteworthy instance, perhaps, is that recorded by Bastian.[3] A man of twenty-six fell about twenty-five feet from a hay-loft. Almost complete paralysis of motion in the leg, with paresis of sensation, partial paralysis of the right arm, and diaphragmatic breathing, followed immediately upon the accident. His back showed no marks of violence and only slight tenderness. After

[1] *Guy's Hosp. Repts.*, 1858, 193. [2] *Lancet*, 1894, i. 670.
[3] *Med.-Chir. Trans.*, 1867, l. 499.

twenty-four days all tenderness, even upon heavy pressure, had disappeared. His voice was weak and the bowels were moved involuntarily, although he was aware of the movement. After brief improvement contractures set in, and he died six months after the accident. The post-mortem showed that there was neither fracture nor compression nor any visible alteration in the structure of the cord. The microscopic examination, however, showed ruptures in the substance of the cord, with hemorrhage in places and extensive secondary degeneration. The sympathetic ganglia were markedly atrophied. In this case, therefore, we see such extensive lesions as to produce even death, though there was neither fracture nor dislocation, nor even any external evidence of injury. In such accidents no operative interference is to be thought of, but only the ordinary hygienic care, with the internal administration of iodide of potassium as a sorbefacient.

The **symptoms** of contusion and sprain (which are apt to be associated with each other) will be shock of varying intensity, proportioned to the degree of violence, vomiting, pain, tenderness, ecchymosis, and swelling if the blow has been a violent one. In not a few cases also the kidneys may be either slightly or severely ruptured, so as to produce bloody urine. Of course, all degrees of injury are met with, and the symptoms, especially the shock, pain, tenderness, and swelling, will vary much in their intensity with the severity of the traumatism. The ecchymosis may be limited to a comparatively small area upon which the blow had been delivered, or it may be very widespread if the injury has been at all extensive. In consequence of the thickness of the skin and the density of the tissues under it, the ecchymosis is apt to be late in appearing. Occasionally a true hæmatoma may form, and, if the blood is not absorbed, may ultimately require incision. Some of the worst cases are those in which a patient may fall from a height and strike upon a beam or an iron bar transversely, so that while the back is arrested by the obstacle the shoulders and head at one extremity of the body and the legs and hips at the other may bend, and most severely wrench the various joints of the spine or produce extradural or subdural hemorrhage, or hemorrhages in the cord itself, though the injury may not be severe enough to produce either dislocation or fracture. Even when the patient has recovered from the immediate accident, there is apt to be left for a long time marked stiffness and lameness from the injury of the muscles and bones and the chronic inflammation of the joints. Sometimes, though rarely, even caries of the bones may follow.

Treatment.—After the treatment of the initial shock and pain by heat, stimulants, and morphine, the first necessity in any such accident is absolute rest. This alone in many cases, especially of the less severe degrees, may be all that is necessary. It should be prolonged for a greater or less time in accordance with the degree of the injury. As an adjuvant to secure rest locally and give support to the parts strapping of either half of the body if the injury be unilateral, or of the posterior two-thirds of the body if it be bilateral, as has been especially advocated by Ashhurst and Wharton, will give the greatest relief. A plaster jacket may also be of great service. Dry heat by means of hot-water bags and bottles will be usually a great comfort to the patient and promote early healing. Of course the condition of the bladder

and bowels will be carefully attended to. When the earlier soreness and the inflammatory reaction have passed by, friction and massage will often be of the greatest value. If the joints are affected, the rest must be more prolonged, and massage and friction should be employed much later. In case there be a spinal lesion, it will be needful, of course, to treat that, whatever the form it assumes, and for both diagnosis and treatment the reader must be referred to standard works upon neurology. (For the remoter results of severe contusions see the section on Railroad Injuries, p. 802.)

Spinal Hemorrhage.—Spinal hemorrhage may either take place in the spinal cord itself, when it is called *hæmato-myelia* (Plate X., Fig. 1), or in connection with the spinal membranes, when it is called *hæmatorrhachis.* In the majority of cases this is extradural, but occasionally may be subdural.

Hæmato-myelia of sufficient degree to cause distinct symptoms is, according to Gowers, very rare and does not admit of surgical treatment. Mr. Thorburn, however,[1] has pointed out that, especially in the cervical region, hæmato-myelia unaccompanied by evidence of injury to the spine is really relatively frequent. He has found it in 6 cases out of 21 of injury to the spine. "The symptoms will depend upon whether the lesion is a 'destroying' or a 'compressing' one, the former being permanent, the latter more or less temporary. A destroying hemorrhage produces atrophic paralysis, and possibly destruction of some of the roots of the brachial plexus. A compressing lesion may cause more or less complete paralysis and anæsthesia below its level, with retention of urine and fæces, priapism, contraction of the pupil, and other symptoms, which, as a rule, soon subside, probably leaving some spastic symptoms in the lower limbs" (Thorburn). Of course the onset is sudden, and there will be, as a rule, little if any fever.

The region of the spine in which hæmato-myelia is most frequently found is from the fifth cervical to the fourth dorsal nerves—that is, the summit of the arch formed by the cervical spine, the point at which acute flexion of the neck would produce its worse results. It is interesting also to note, in addition to the symptoms already detailed, that the anæsthesia involves not only the trunk below the seat of the lesion, but often also the inner aspects of the arms.

In hæmatorrhachis the blood may be found outside the membranes (extradural hemorrhage), within the dura (subdural hemorrhage), or under the arachnoid (subarachnoid hemorrhage). In the extradural (extrameningeal) form the amount poured out is rarely enough to produce compression. In subdural hemorrhage, and sometimes in extradural (compare case below) it has been known to pass from one end of the cord to the other. Browning has suggested that puncture of the spine (p. 852) by an aspirator needle may be of value in making the diagnosis. Neither form is, as a rule, amenable to surgical intervention, though Mills has suggested the possibility of trephining at two points to secure suitable drainage.

The **treatment**, of course, should be absolute rest, attention to the hygiene of the patient, and for a time the administration of the iodide

[1] *Surgery of the Spinal Cord*, p. 62.

PLATE X.

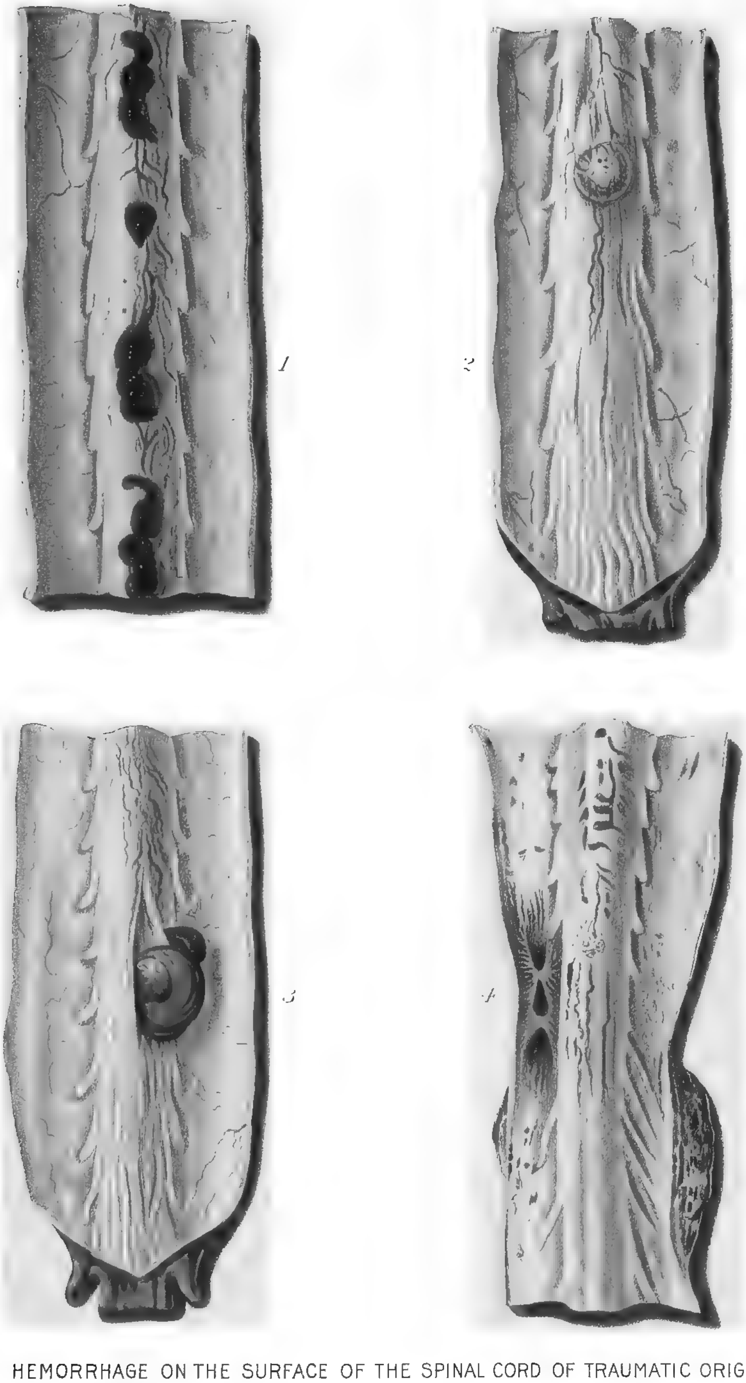


FIG. I HEMORRHAGE ON THE SURFACE OF THE SPINAL CORD OF TRAUMATIC ORIGIN.

FIG. 2 SARCOMA OF THE SPINAL CORD.

FIG. 3 SARCOMA OF THE SPINAL CORD.

FIG 4 MENINGITIS AND BEGINNING COMPRESSION MYELITIS FROM AN EXTRA-DURAL TUMOR (BOCK.)

of potassium and mercury. It is not unlikely that hereafter operative treatment may be sometimes resorted to with advantage.

Through the courtesy of Dr. Edward Martin and Dr. Charles S. Potts, I am able to give the following résumé of an extremely instructive recent case of hæmatorrhachis which was operated on, and, but for the injury to the cord itself, the patient might have recovered. It is, I believe, the first case of neurological diagnosis and purposeful laminectomy for this cause, and reflects great credit upon the physicians. The man was injured by rolling down a steep embankment while drunk. He was brought to the University Hospital early on a Sunday morning with minor wounds, but no other symptoms than those pertaining to his alcoholism. By 1 P. M. he felt so well that he desired to go home. At 7 P. M. paresis of the legs was noticed, which an hour later had increased to complete paraplegia, the line of the anæsthesia being on a level with the anterior superior iliac spines. There was also, for a time, suppression of urine. By 1 P. M. on Monday the paralysis had increased, so that the abdominal and intercostal muscles were involved as well as the legs, the patient breathing with the diaphragm alone, and the line of the anæsthesia had now crept upward until the lowest point in front was on a level with the nipples, from which point it curved up toward the axillæ. The superficial reflexes were absent. The knee-jerks and the pupillary skin-reflex were not tested. There was no pain except a slight girdle-pain, and no deformity in the cervical region, though Dr. Martin thought he detected a boggy feeling there which indicated possible fracture. By 2 o'clock P. M. the level of the anæsthesia had crept still farther upward, and the ulnar areas of both hands, but not of the forearms, were anæsthetic. There was also noticed some marked weakness in the muscles of the forearms (both flexors and extensors), but owing to the man's condition it was impossible to examine each muscle. Above the level of the complete anæsthesia was a space about an inch broad which was paræsthetic. Drs. Martin and Potts made the diagnosis of hemorrhage, the blood having first sunk down to the level at which the paralysis first appeared, and then, as the spinal canal filled up with blood, the anæsthesia rose higher and higher. The highest point of the spine involved was diagnosticated to be at the sixth cervical segment. Dr. Martin made a laminectomy, and found the third and fourth cervical laminæ fractured, with continuous bleeding. On enlarging the opening in the canal farther down a clot was found opposite the fifth and sixth cervical vertebræ. The advisability of making a second opening lower down for removal of any lower clot and drainage was considered, but the patient's condition was such that it was deemed best to stop. He died at 4 A. M. on Tuesday, twelve hours after the operation.

While there was no amelioration of the symptoms, there was no further involvement of the additional areas of motion or sensation. The autopsy showed extradural clots in the spinal canal, reaching down some distance into the dorsal region. In the fourth cervical segment there was also a hemorrhage into the gray matter of the cord.

Coccygodynia.—Coccygodynia was first accurately described by Nott of New York in 1844, and more minutely by Simpson in 1859. It consists essentially of pain in the region of the coccyx—pain which is persistent and severe in most cases. It is produced especially by sitting,

and makes this in some cases almost impossible, so that the patient is obliged always to sit sidewise.

It is caused either by contusion or fracture, or possibly in some cases by cold. In not a few it has been presumed to result from injuries received during childbirth. The large number of sensitive nerves distributed in the region of the coccyx may possibly be a reason for its existence.

Treatment.—The treatment recommended by Simpson was subcutaneous division of all the structures about the coccyx, but in general the better treatment is that of Nott—namely, entire extirpation of the bone. This is effected by a single linear incision. Only a careless surgeon could inflict injury upon the rectum. It can also be burred away by the dental engine (Garrettson).

Railroad Injuries of the Back, the so-called "Railway Spine."

Since the introduction of steam railroads and the large number of accidents to which they have given rise, and the consequent litigation for obtaining damages, these injuries have assumed great importance, especially in medico-legal cases. The injuries to the spine from such accidents consists essentially of physical contusions of the soft parts and bones; of severe sprains of the spinal joints; sometimes, though rarely, of real injuries to the cord; and especially the mental effects best described by the terms "shock" or "fright." Of course, in very many cases there are distinct fractures or dislocations of the vertebræ. These when produced in railroad accidents differ in no respect, save in the mental fright which accompanies them, from similar injuries received in other ways. But in using the term "railway back" or "railway spine" it is understood that such actual physical lesion as fracture or dislocation is excluded.

Symptoms.—The symptoms will vary in individual cases from those of slight gravity to those of such importance as to threaten life itself. Sometimes the patient may be unconscious. In other cases, though without losing consciousness, he will receive a more or less severe injury to the spine, which will develop the ordinary symptoms of contusion and sprain, etc., such as inability to rise—sometimes even of paralysis, especially of the lower extremities. There may be even hæmaturia, though this is not very common. In other cases the patient immediately after the accident is not aware, apparently, at first that he has been injured at all. It may be that, extricating himself from the wreck, he will be able to assist others seemingly less fortunate than himself, and one or two days may elapse before the physical signs will develop. In addition to the physical conditions mentioned, however, there is perhaps no class of injuries in which the mental shock or fright is greater than in railway accidents, especially if they occur in the darkness of the night or in connection, it may be, with precipitation into a river or brook, or if part of the train takes fire. Besides this, it is not uncommon that fellow-travellers or relatives or friends, sitting possibly in the next seat, are instantly killed or so pinned down by fragments of the wreck as to produce the most intense pain. The shrieks

and moans of the wounded or the drowning, the gradual approach of fatal fire, the suddenness of the accident, the darkness—in fact, everything connected with such disasters—are calculated to produce the most profound shock or fright that one can imagine. For weeks when the victim of such an accident falls asleep he is apt to waken in terror, fearing that the engine is upon him. This peculiar and excessive fright seems to be the chief factor which marks this class of accidents as one apart from all others. That it often develops later a condition of neurasthenia, or in some cases, even in men, what is rightly called a traumatic hysteria, is therefore no wonder.

Sometimes the fright is so great as to cause a belief in absolutely non-existent injuries. Page[1] gives an example of a man who was in collapse from supposing that his foot was crushed, when in fact only the heel of his boot had been torn off. Case 10, related by Page (p. 31), is an example of a tall, powerful man who received only slight physical injuries, and yet four years after the accident was an old, haggard invalid, chiefly from the shock. In his Case 15 (p. 47) even death took place five weeks after the collision without any perceptible injury, the post-mortem (which included an examination of the brain and cord) showing no structural change whatever. On pp. 797, 798 two cases of serious and extensive disease from slight falls are related.

The later symptoms of such railway injuries are vague pains, lameness and stiffness of the back, tenderness at various points, affections both of motion and sensation, especially the inability to move this or that part of the body, the back itself often being bent stiffly at the hips, and the body inclined to the right or left side, with inability to rotate the shoulders. Disorders of sensation also follow, such as anæsthesia, or, more frequently, marked hyperæsthesia, with sensations either of numbness or of pins and needles, especially in the lower extremities. Failing eyesight, especially in the form of asthenopia, is very often complained of, though there seems to be no evidence of changes in the retina or other ocular structures which will account for the disturbances of vision. Speech is apt to be short, jerky, or feeble, and the patient, especially his legs, is not uncommonly subject to tremor. The skin may be moist from moderate, or in some cases profuse, sweating. The urine is superabundant, and the patient often has to empty the bladder several times in the night.

The mind is apt to be dazed or confused for a greater or less length of time, and the patient is nervous, unable to concentrate his attention either on his business or other pursuits. Travel, especially by railway, and often even simple driving in a carriage, becomes torture from the constant dread of accident. The patient is unable to attend to his usual occupation or to take up any new one. He is depressed and gloomy, and regards the future with the greatest apprehension, fearing that he never may be able again to earn his living or support his family. Of course there are all degrees in these symptoms, many being entirely absent or slightly marked in some cases, and in others this or that symptom will assume unusual prominence.

Of course, in such subjective conditions there is always a large field for fraud. It is very easy for a patient to assert that he cannot move

[1] *Railway Injuries*, pp. 27, 28.

without pain, that his sight is imperfect, his memory failing, and that he is excessively nervous and confused, and in some cases it is extremely difficult to decide with anything like certainty that we are dealing justly and truthfully in deciding that these symptoms are real or that they are fictitious.

As a whole, they have been aptly named "litigation symptoms," and are among the easiest to assert and the most difficult to disprove in any court. Moreover, numbers of these patients, after having received, it may be, large compensation for their injuries, have recovered with marvellous speed after months, or in some cases even years, of asserted disability, thus undoubtedly tending to cast a reproach upon honest sufferers and cause railway companies naturally to suspect every such person, in whom there is no physical evidence or only slight evidence of injury, of attempting to extort money from them by pretended or exaggerated injuries.

In one respect it is very easy to see how even a real sufferer, it may be a poor workman, worried by the prospect of long and extensive litigation, while meantime unable to earn a decent living for his family, once that he has settled his claim and received even what he may regard as insufficient compensation will be in a wholly different state of mind from what he was before the settlement of the suit, from the comparative temporary affluence that this brings. Two thousand or three thousand dollars to such a laboring-man is a large sum, and although it will not support his family for a very long time, and its income will be moderate, yet the possession of so much money gives instant relief to what may have been absolute want, so that the cheerfulness and hopefulness which follow such a settlement may have a real and powerful influence in promoting his recovery, when the uncertainty and doubt before the settlement have depressed him and retarded or even prevented his recovery.

It is therefore a matter of great importance to be able as nearly as possible to determine whether a patient is endeavoring to extort by fraud and exaggeration from the railroad company compensation to which he is not entitled, or whether a man who asserts that he suffers in certain ways is really and honestly stating the facts. There have been a number of cases of such accidents in which the question of damages did not enter, and yet such vague but real neurasthenic symptoms have been present, and the inability to work has caused great suffering both to the patient and his family. These cases are too numerous for us to doubt the possibility of their being sequels to such accidents. Potts[1] has related eighteen such cases.

In estimating the truth or falsity of such statements it is important not to take any individual symptoms, but the *tout ensemble* or aggregate of them all. Again, it is important to consider the general effect produced upon the surgeon's mind during the examination as to the apparent truthfulness and candor of the patient, or his evident desire to exaggerate the symptoms and impress upon the surgeon their gravity.

Dercum has proposed to "exclude all pains the existence of which cannot be confirmed by any physical evidence, and which rest wholly upon the unsupported statements of the patient," and that, on the other hand, "all pains, signs of which are evoked without previous warning or

[1] *Univ. Med. Mag.*, 1892-93, v. 777.

suggestion, should be rigidly admitted." While possibly going a little too far in discrediting the statements of the patient, yet in general these two rules will serve our purpose and enable us to reach a just conclusion. In his excellent paper on "The Back in Railway Spine"[1] he has drawn attention to a method of examination which seems to be of especial value. The pains in these cases can be divided into the superficial and the deep. The superficial tender spots, which are purely functional, though also genuine, can be distinguished sometimes by the injection of cocaine or, as I would suggest, of plain water at one of the painful spots, which in a very short time will disappear, while the others above and below will remain. In such cases we cannot doubt the real existence of the pain if the patient has not been aware of what has been done. That the hypodermatic injection of plain water is distinctly analgesic I well know personally. In an attack of lumbago some years since I had some plain water injected under the skin, and, though I knew it was water and presumably would have no therapeutic effect, yet the pain disappeared within a very few minutes and the attack was completely cured by it.

Pain on deep pressure differs from the superficial variety by being much less sensitive, less suddenly developed, and has no element of hyperæsthesia. It is more diffuse, and is more apt to be at the point which has been directly injured; whereas the superficial tender spots often have no special relation to the locality of the injury. Percussion, especially with a rubber hammer, such as to produce decided jarring of the spine, will not uncommonly elicit pain even in a bony structure, though produced by blows which of themselves are not painful. The pain which is elicited manifests itself not only in stiffness and in the attempt to prevent motion which is being effected, but will not uncommonly show itself by localized muscular spasm—a symptom of the greatest possible value, because it is one which cannot be simulated. Thus I have seen in several cases spasm of the erector spinæ muscle on one side only, so marked that the muscle would be thrown into relief and be almost as hard as the contracted biceps—a muscular action which it is utterly impossible for any one voluntarily to produce, just as the board-like tension in the right side of the abdomen in appendicitis is a symptom which cannot be simulated. Those who are endeavoring to deceive can often be trapped by unexpected movements, or by pressure upon or movements of one part of the body while the attention is directed to another part. Not only should the body be bent forward and backward, but lateral flexion should also be employed, and torsion of the body by turning the shoulders while the hips are fixed as rigidly as possible. In addition to this, by pressure upon the head while the patient is sitting or standing erect, or by the hands on the shoulders, a sudden impulse or shock can be sent through the spine which will test especially (as does also torsion) the condition of the joints and the intervertebral substances. Of course such physical signs as sweating, vomiting, especially if blood is vomited, and the passing of bloody urine, cannot readily be simulated, and should have due weight along with other symptoms that have been described. The reality of alleged sleeplessness is difficult to ascertain unless the patient be under observation

[1] *Am. Journ. Med. Sci.*, Sept., 1891.

in a hospital. Sometimes I have detected simulation by a pretended use of the battery, the electrodes being applied as usual, but one of the cords being concealed in the hand, disconnected from the electrode. The malingerer will complain of severe pain; the honest sufferer will state that he feels nothing.

Treatment.—After such a severe mental, and sometimes severe, physical shock the first and most essential element in treatment is absolute rest of both body and mind. The quieting effects of such mental and physical rest cannot be too highly appreciated. In all cases as soon as possible the mind should also be freed from the worriment and anxious excitement of a lawsuit, and, as a rule, it is better in such cases to settle even for a smaller amount rather than to continue the legal fight. Hopefulness should be encouraged as far as possible. This physical rest can also be aided by the strapping or the plaster jacket advocated in ordinary sprains or contusions, by the application of dry heat, and by such hygienic attention to diet, the condition of the bowels, and bladder as may be necessary. Not infrequently after such an accident the catheter is required for a greater or less length of time. Great care, of course, should be exercised to see that it is kept in an aseptic condition. After the primary soreness has passed off, massage, electricity, and, as early as possible, active exertion in the shape of sitting up, walking, driving, or riding, should be insisted upon, and change, both physical and mental, should be brought about by travel or, best of all, by work, especially the ordinary daily work that the patient is accustomed to. While rest is therefore very important at first, it is equally important to see that it is not too long continued. Not uncommonly a modified or even the full Weir-Mitchell treatment for neurasthenia will give the happiest results. Dercum[1] has related an excellent and striking case of almost complete recovery by such a treatment in which no question of litigation was present.

Wounds of the Back.

Incised wounds are inflicted by cutting or puncturing instruments, such as knives, dirks, swords, bayonets, arrows, etc. Lacerated wounds also are caused by falls on blunt bodies or by falling bodies, but especially in war by shot and shell. They may involve only the soft parts, but also may penetrate into the cavity of the chest or abdomen, and may wound arteries of greater or less importance. Such wounds in the cervical region may occasionally involve the vertebral artery and give rise to either primary or secondary hemorrhage, which is often quite severe, or may produce false aneurysms. Whether the aneurysm has arisen from a wound of the vertebral or of the carotid is often very difficult to diagnosticate, and Liddell[2] states that in eleven cases the carotid has been tied by error. There are two ways by which such an error may possibly be avoided: first, by passing a loose ligature around the carotid, the most accessible artery, and testing by temporary compression, without tying the ligature, whether this arrests the hemorrhage, or the dissection may be carried far enough to determine the relation of the aneurysm to the carotid. Other arteries may also be wounded, such as the occipital or the branches of the thyroid axis.

[1] *Alienist and Neurologist*, St. Louis, Oct., 1893. [2] *Internat. Encyc. Surgery*, iv.

If the cavity of the pleura or of the abdomen has been opened, and especially if the viscera have been wounded, it adds, of course, very much to the gravity of the lesion, though such a wound is by no means necessarily fatal. For instance, Liddell[1] relates the case of a teamster who was stabbed in the back, "the left pleural cavity being freely opened, so that air in large quantities was drawn into and expelled from that cavity by each respiratory movement." Even in the days of pre-antiseptic surgery treatment of this wound by interrupted suture and strips of adhesive plaster resulted in healing almost entirely by first intention.

The spinal cord, of course, may also be wounded. This accident is considered below.

Treatment.—If the wound be one involving only the soft parts and without penetrating any cavity, the ordinary treatment of an incised or lacerated wound by disinfection, suture, and antiseptic dressing is sufficient. If any large arteries are involved, the extensive exploratory operations which modern antiseptic surgery has made allowable and the use of hæmostatic forceps—the most valuable mechanical aid that has been added to the armamentarium of the modern surgeon—make a successful treatment in most cases very possible.

Matas[2] has discussed the treatment of wounds of the vertebral artery, and has shown that packing, pressure, the hæmostatic forceps, and the ligature make the lesion much less formidable than formerly. In penetrating wounds the most careful disinfection or aseptic treatment is essential. If the thorax or abdomen is simply opened, the opening should be closed by buried sutures and the lips of the wound approximated as usual. If there be a wound of any of the viscera, such as the lungs, kidney, liver, spleen, or other organ, the treatment must be in accordance with the severity and extent of the wound.

Hemorrhage is to be arrested either by pressure, the ligature, or the Paquelin cautery. If the kidney or spleen should be hopelessly injured, it should be removed. The further consideration of such wounds does not properly fall within the purview of the present paper.

Gunshot wounds are considered on p. 829.

Wounds of the Back involving the Spinal Column and Spinal Cord.

Although so efficiently protected both by the soft parts and the bony canal in which it lies, occasionally the spinal cord is injured by accidents, such as falling on a chisel or other sharp instrument, when a patient is stabbed by a knife, or in war when the spine may be injured by either an arrow or more frequently by the ordinary missiles of war. Sharp instruments, such as knives, chisels, and splinters, most readily wound the cord in the cervical region, since the spinous processes are more horizontal and the space between them wider than elsewhere; but even in the dorsal region a knife may penetrate the bones and thus wound the cord (Fig. 464).

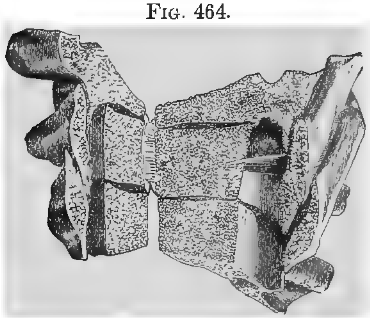
The wounds caused by the instruments described above may involve either the bones alone, laying bare the membranes or not, as the case

[1] *Loc. cit.*, iv. 268.

[2] *Annals Surg.*, 1893, xviii. 477.

may be; may wound the membranes alone, the cord escaping; or the cord may itself suffer, either by a total division or occasionally a hemi-section—viz. division of the right or left half more or less exactly. In case the bones only are injured, there would be no special symptoms, but if the membranes are lacerated or incised, there would be first of all an escape of the cerebro-spinal fluid. Of course it is possible, though exceedingly rare, that the ureter might be wounded, but the difference, in the first place, of the character of the fluids, the one having a urinary odor, the other showing the chemical constitution of the cerebro-spinal fluid and the absence of the urinary odor, the comparatively large initial quantity and more or less steady flow of the cerebro-spinal fluid, contrasted with the small amount and intermittent escape of the urine, would establish an almost certain diagnosis. Later, especially if the wound become infected, there would be developed spinal meningitis, which would establish the diagnosis. Holmes[1] refers to three cases in which the membranes only were wounded, with escape of the cerebro-spinal fluid.

Fig. 464.



The fourth, fifth, and a part of the sixth dorsal vertebræ, sawn open to exhibit the blade of a knife which had broken off after traversing the spinal canal and spinal cord (specimen 1160, Army Medical Museum).

If the cord itself is involved, there will be paralysis more or less complete in accordance with the extent of the division, or in gunshot wounds which destroy the spinal cord complete paralysis both of motion and sensation. Should the division of the spinal cord be unilateral, there will then be a crossed paralysis—*i. e.* paralysis of motion on the same side as the hemi-section, and paralysis of sensation on the opposite side —and very possibly later there may be developed other lesions of the cord and spinal arthropathies. A very excellent illustration of such lesion is found in Charcot.[2] Neumann[3] reports 5 such cases of hemi-section with 4 recoveries, and Kiär[4] has reported another with recovery.

The paralysis after wounds of the cord will not be limited to the extremities, but will affect also the bladder and bowels, causing at first marked constipation and retention of urine, to be followed almost invariably by incontinence of urine, and sometimes of fæces. Bed-sores are also extremely apt to form, not only as a result of the prolonged motionless attitude from the paralysis, but also by reason of the great difficulty of keeping the patient clean and dry in consequence of the involuntary and, in fact, unconscious escape of the urine and fæces.

In hemi-section by limited incised wounds of the cord the cases above cited show that if infection is avoided the cord has an unexpected and gratifying power of almost complete recovery. Thus Meryon and Schwandner,[5] Hurd,[6] Peniston and Viguès[7] report cases of such incised wounds by sword, dagger, chisel, etc. in which complete or almost complete recovery took place.

[1] *Lancet*, April 29, 1882. [2] *Diseases of the Nervous System*, Philadelphia ed., p. 70.
[3] *Virch. Archiv*, cxxii. [4] *Lancet*, 1894, i. 692.
[5] Ashhurst's *Internat. Encyclop. Surg.*, iv. 270. [6] *Ibid.*, p. 393. [7] *Ibid.*, p. 394.

Treatment.—Ordinarily there is no serious hemorrhage in consequence of such wounds, but sometimes large vessels may be wounded, and of course in gunshot wounds even the aorta and vena cava may be wounded. Such wounds, of course, are almost instantly fatal. If large vessels are cut, they must be dealt with as usual in hemorrhage. In the neck it is possible that the vertebral artery may be wounded and give rise to a serious primary or secondary hemorrhage or to aneurysm. The whole subject of the surgery of the vertebral artery is exhaustively considered by Matas. (See p. 807.)

It is almost needless to say, in these days of antiseptic surgery, that in all the manipulations for the ligation of vessels or for other purposes the strictest antisepsis should be employed. No instrument or finger should touch the wound unless it has been disinfected. A wide area around the wound also should be disinfected. The disinfected probe should be sparingly used, and in most cases will not be required, as the symptoms will lead up to a more or less accurate diagnosis of the nature and extent of the lesion. If any fragment of the vulnerating body is left in the wound, and especially in the cord, it should be removed by laminectomy (p. 858) if necessary. If no such fragment is broken off, and there is no evidence of a broken fragment of bone pressing on the cord, and if no hemorrhage of importance is found, the treatment should be limited to a thorough disinfection of the wound and the surrounding skin and the application of an antiseptic dressing. The bladder and bowels should be carefully looked after, the diet regulated, pain relieved, and every means taken to ensure a speedy healing of the wound. In time electricity, massage, and the other usual means for keeping the paralyzed muscles in good condition should be used. The prognosis is not, however, very encouraging. Chipault states that Thorburn has collected 34 such cases with 21 recoveries, 3 of which were complete, 16 with persistent motor or sensory troubles, and 2 were bettering when last seen. The recovery of the cord in these as in most other wounds is rarely perfect.

Among the symptoms that are caused by all kinds of wounds involving the spinal cord itself, whether incised wounds, gunshot wounds, fractures, or dislocations, two demand special consideration—viz. bed-sores and the effects of such injuries to the cord upon the urinary organs.

Bed-Sores after Injuries to the Spinal Cord.

The bed-sores which follow injuries to the spinal cord are of two different kinds: First, the ordinary bed-sores, or local gangrene from pressure; second, the neuropathic bed-sore.

1st. *Ordinary Bed-sores.*—These occur over projecting bony points exposed either to friction or pressure; for instance, over the coccyx and lower sacrum, the great trochanters, the spines of the scapulæ, the heels, the inner condyles of the humerus, and occasionally the occiput, the knees, and the malleoli. They are caused both by pressure and by friction, and are really a local gangrene of the soft parts over these bony projections. Over the coccyx and sacrum (or rather under them as the patient lies in bed) the occurrence of such bed-sores is favored very

much by the decomposing moist urine and fæces and other sources of irritation, and by irregularity of the bed-clothes, bread-crumbs, etc.

2d. *Neuropathic Bed-sores.*—These are not due so much to the simple section of the cord as to the irritation from splinters of bone, blood-clot, or myelitis, as shown especially by Brown-Séquard. They form not only at such points as the ordinary bed-sores, where pressure and friction assist in their production, but may form at points where there is no such pressure, as, for instance, in the case of Conant,[1] in which after a fracture in the lumbar region the patient had such neuropathic bed-sores form on the inner side of the thighs.

When such a bed-sore is about to form there will first appear erythematous patches, most frequently in the skin over the sacro-coccygeal region, followed by the formation of a more or less large blister and mortification or gangrene of the skin. Such gangrenous patches will form not uncommonly in thirty-six or forty-eight hours, and have been seen even in less than twenty-four hours. Along with this the urinary changes noticed below will be very apt to follow. If the spine has suffered a hemi-section, the bed-sores will appear not in the middle line, but on the opposite side to the wound. In other forms of bed-sores, as I saw in especially severe cases in the field hospitals during the late Civil War, the most extensive sloughing of the skin may lay bare the whole of the coccyx and a large part of the sacrum. The skin may be undermined sometimes for two or three inches all around the opening, and not uncommonly the spinal cord will be invaded by the putrid discharges from the wound at the point where the posterior arches of the vertebræ are imperfect at the lower extremity of the sacrum, and an extensive meningitis may follow. Sometimes the patient will die from acute septicemia, or, as in one of my own cases, from acute tetanus.

Treatment.—By far the most important treatment of both forms of bed-sores is prevention. The possibility of the extremely early occurrence of bed-sores from spinal injuries should be remembered, and not a day should pass without an examination of the back, especially of the sacrum and coccyx. The patient's posture frequently can be changed but little, but the effects of pressure can to some extent be avoided by the use of a water-bed, by rings or rubber cushions, and by bathing the back at least twice a day with a saturated solution of alum in alcohol.

In addition to this, the utmost cleanliness should obtain, and frequent examination should be made to see if urine and fæces have escaped, and the patient should not only be cleansed, but should be powdered with rice-powder, lycopodium, talcum, or such other powder as may answer the purpose. All creases or other irregularities in the bed-clothes must be strictly avoided, and when the patient is fed the greatest care must be taken that bread-crumbs, etc. do not fall into the bed. Should a bed-sore form, my experience, especially during the war, leads me to commend the treatment introduced by Brown-Séquard—viz. the application of an ice-poultice for fifteen minutes, followed by a hot poultice, or, better still in these days, by a hot antiseptic fomentation for two hours. The best method for applying the ice is by breaking it into small pieces, rounding off the sharp corners by warm water, and mixing them in a cold bran or flaxseed poultice. To answer the demands of antiseptic

[1] *Amer. Med. Times,* June 1, 1861, 359.

surgery it would be better to substitute for this poultice ice-water or finely-cracked ice in a rubber bag outside of a few layers of antiseptic gauze. When the slough has separated from the skin, the ulcer can be dressed with carbolated vaseline or the ordinary oxide-of-zinc ointment. The internal administration of iodide of potassium and ergot has been thought useful.

Urinary Disturbances after Spinal Injuries.

Usually the first symptom of disturbance of the urinary organs is the inability to empty the bladder—*i. e.* retention. Hence the condition of the bladder should be looked to from the very start. If retention occurs, the catheter must be used, and the most scrupulous care should be given to the condition of the catheter. It must be remembered that there is scarcely any surgical instrument that is so difficult to keep thoroughly clean. It should be kept constantly in a solution of carbolic acid, and immediately after use it should be cleaned by passing hot water through it, or, better still, if a metal instrument, by boiling, and then it should again be placed in the carbolic solution. When it is used it must be anointed with carbolated vaseline or with carbolic oil.

Retention is soon followed by incontinence of urine. In consequence of the atony of the bladder there will often be a considerable amount of urine retained even when it is escaping almost continually. Hence the retained urine very soon undergoes decomposition, and becomes alkaline and phosphatic, especially if an unclean catheter has been used and has infected the urine. Large quantities of adherent mucus also will soon cloud the urine. In consequence of the catarrhal condition of the mucous membrane of the bladder, which results from the altered urine, it does not take long for such decomposing urine to affect the kidney, and a nephritis or pyelo-nephritis, with, it may be, abscesses, and disorganization of the kidney—the so-called surgical kidney—almost invariably follows. No one symptom of spinal injuries is more important or more dangerous than this involvement of the bladder and the kidneys, and hence the utmost care should be taken to prevent any infection, especially through the catheter. Even though no catheter has been used, such cystitis and later involvement of the kidney are almost sure to follow in the case of severe and prolonged illness.

The urinary involvement has been considered by Lauenstein and others as one of the chief indications for a laminectomy.

Treatment.—The treatment of such conditions is very unsatisfactory and ineffective from the very nature of the case. Much can be done, however, first by scrupulous cleanliness as to the use of the catheter, and the aseptic condition of the urine can be favored not a little by the internal administration of salol, boric acid, and possibly, though I have tried it only in a few cases, by small doses of saccharine,—all of which tend to keep the urine in an aseptic condition.

Fractures of the Spine.

About 20 per cent. of these injuries are fractures alone, about 20 per cent. dislocations alone, and about 60 per cent. consist of both fracture

and dislocation and are known under the compound name of "fracture-dislocations." I shall first consider fracture-dislocations, with incidental allusions to fractures alone; secondly, dislocations alone; and thirdly, gunshot fractures, which have some peculiar features about them.

Though the injury to the bones (for often several vertebræ are fractured) may be extensive, this is the least important feature of the case. As in fractures of the skull the injury to the brain is the predominating factor of importance, so in fractures of the spine it is the injury to the cord which is of such vital moment, since it may produce paralysis of motion and of sensation, cause loss of control of the bladder and rectum, and is very frequently and speedily followed by large bed-sores, one of the most distressing and fatal results of such an injury. The origin, nature, and treatment of such bed-sores have already been considered in the previous section (p. 809).

Fractures of the vertebræ, as other fractures, may be either simple, compound, or complicated. A simple fracture is frequently complicated by injury to the cord. This injury to the cord is produced either by permanent displacement of the fragments or possibly by diastasis—*i. e.* sudden separation of the fragments with recoil into their former places. Chipault,[1] basing his conclusions upon a very large number of cases, does not believe that such a temporary displacement occurs. He believes that the cases which seem to show such a diastasis are those in which the reposition has taken place post-mortem, as they are cases in which death has followed at an early date before any callus has fixed the bones in their displaced position. Those cases which live long enough to be so fixed by callus always show permanent displacement. Thorburn,[2] on the contrary, believes them to be frequent, and that in the cervical region they are twice as common as those in which there is permanent displacement. In either form of fracture, even if the vertebræ have returned to their former position, the cord may be so severely injured that it is reduced to a pulp or torn into shreds. Such an injury is almost certain to be followed very speedily by inflammatory softening.

The frequency of fractures of the spine is, fortunately, not very great in proportion to the number of fractures elsewhere. They constitute about 3 or 4 per cent. of the total number of fractures. They are more frequent in the cervical and dorsal regions, and less so in the lumbar. They are more frequent in middle life and in males, on account of the exposure of adult males to occupational injuries.

The bodies are much more frequently fractured than the arches. The displacement is often so great that the cord is completely crushed between the fragments of the fractured and dislocated bones. Even when only the arches are broken, fragments may be thrust into the cord and produce extensive laceration. On the other hand, it is not at all infrequent that there may be fractures of the spinous processes alone or of the arches without injury to the cord. Such fractures are uncomplicated, and follow the natural course of a fracture of a bone in any other part of the body. Occasionally the odontoid processes of the axis is fractured and presses upon the cord. Dr. Stephen Smith over twenty years ago collected 24 cases of such fractures.[3]

[1] *Études de Chir. médull.*, pp. 79–81.
[2] *Brit. Med. Journ.*, Oct. 27, 1894.
[3] *Amer. Journ. Med. Sci.*, Oct., 1871, 338.

Causes.—Fractures of the spine are most frequently caused by falls, blows, railroad accidents, or the caving in of embankments, etc., all of which may inflict very extensive injury. Sutton [1] records the case of an intra-uterine fracture of the spine, the result of a fall of the mother at the fifth month of gestation. At the birth of the child, at the eighth month, the upper part of the body was correspondingly developed, but the development of all the parts below the level of the navel were those of an embryo of five months, all the soft tissues of the legs being reduced to adipose tissue—a striking instance of retrograde metamorphosis of tissue from deprivation of nervous influence.

Symptoms and Diagnosis.—If the fracture be compound, the disinfected finger or probe, which should be used very cautiously, may detect easily, or sometimes with difficulty or even not at all, the fragments of bone. If the fracture be simple and is limited to the spinous processes or the arches, very possibly mobility may be detected by manipulation. If the fracture be through the bodies of the vertebræ, the three characteristic symptoms of fracture—viz. deformity, crepitus, and preternatural mobility—may all be absent or detected with great difficulty. In some cases there will be very marked deformity—as, for example, when a man driving under an archway has struck against the summit of the arch and been doubled up by it—but often the deformity is slight or absent.

No attempt should be made to elicit crepitus, except of the spines or possibly of the arches, since the attempt may increase the damage to the cord. The same caution would apply to any attempt to determine the existence of preternatural mobility. It is rather upon the general symptoms attendant upon the injury, and especially upon the symptoms of injury to the spinal cord, that we base the diagnosis. There will usually be great shock, marked local tenderness at the site of the injury, pain, increased upon movement, and especially a girdle-pain surrounding the body at the level of the injury. The reflexes will be variously affected, as noted below. The bladder and bowels may be paralyzed, and either arms or legs, or both, may also be paralyzed, either as to motion or sensation, or both. Soon muscular twitchings set in, accompanied or followed by the ordinary symptoms of traumatic myelitis, with severe bedsores and cystitis. The symptoms will vary considerably with the level of the injury.

Fracture of the Lower Three Lumbar Vertebræ.—This is very rare. The injury is below the spinal cord, and may involve the nerves of the cauda equina, which, however, not uncommonly escape, in which case there will be no paralysis. If the nerves are involved, there will be greater or less paralysis of the legs according to the extent of the injury. The gait is apt to be feeble.

The **prognosis** is good both as to life and function. If the injury involve the lumbar swelling (and fracture of the twelfth dorsal and first lumbar are the most frequent of all in this region, for the reason given on p. 836), there will be paralysis of the muscles with reaction of degeneration. The bladder and bowels also are commonly paralyzed and often tympanitic. If ascending myelitis follow, the paralysis may extend much higher, and even involve the arms at a later period. There is apt

[1] *Gen. Pathol.*, p. 85.

to be a visible angular deformity, and crepitus may be present. The prognosis is better than in fractures at a higher level.

In the *dorsal region* the paralysis will extend to a higher level, corresponding to that of the injury. The atrophy of the muscles of the lower extremities will most likely be absent, since they are still in connection with the lumbar cord.

In the upper portion of the dorsal region the voice may be weak; there may be dyspnœa from interference with the function of the intercostal muscles. The skin becomes branny, the bowels tympanitic, and there may be marked and continued priapism.

In the *lower cervical region* there will be paralysis of the upper extremities, sometimes incomplete, from a partial lesion of that part of the cord from which the brachial plexus arises. The respiration will be diaphragmatic, and dyspnœa will be very marked, especially in expiration; the voice very weak; priapism will be more frequent and marked; and there is not seldom hyperpyrexia (108°–110°–112°). Teale[1] has recorded a case in which it reached 122°, yet the patient recovered. Death often follows from the initial difficulty of respiration or is caused by the ascending myelitis.

In the *upper cervical region* there is sometimes marked pharyngeal swelling. The paralysis of respiration is often so complete that almost instant death takes place from the shock and absolute paralysis of the intercostal muscles and the diaphragm from the involvement of the phrenic nerve or from the destruction of the respiratory centre in the medulla oblongata. The peculiar posture of the patient, according to whether the fifth-root group is or is not involved, is described on p. 817. The fifth and sixth cervical are the most frequently fractured.

Fractures of the Atlas and Axis.—These are often immediately fatal from involvement of the respiratory centre. Life may be prolonged for some time, but then be suddenly terminated in consequence of displacement of the fragments with pressure on the medulla. The diagnosis from dislocation of the same vertebræ is almost impossible except by a post-mortem.

The *determination of the level at which the lesion exists,* however, should be more exactly made than by these general symptoms. As yet we are not able to determine this with the exactness that is desirable, but a close approximation can be made to it.

There are *three methods* by which the level of the injury can be determined. First, the extent of the motor paralysis; secondly, the extent of the sensory paralysis; and thirdly, the condition of the reflexes connected with each segment of the spinal cord. From the three together we can judge with fair accuracy what nerves, and therefore what spinal segments, are involved.

First, the Extent of the Motor Paralysis.—The spinal cord may be considered as made up of a series of horizontal segments placed one on top of another like a pile of checkers, one pair of nerves, right and left, arising from each segment—*e. g.* the fifth cervical segment would be that segment of the spinal cord from which the fifth cervical nerve-roots take their origin, and the fourth segment that portion of the cord from which the fourth pair of spinal nerves take their origin,

[1] *Lancet,* March 6, 1875.

and so on. In the following table of localization of the functions of the segments of the spinal cord the first column gives the various segments of the cord; the second column, the muscles supplied by the nerve or nerves arising from each segment; the third, the reflex which has its origin in such a segment; and the fourth the area of sensation—that is to say, the area of skin supplied by such nerves. The table is founded on one by M. Allen Starr[1] and elaborated by Mills.[2] Very probable future observations will correct errors in the table. In Thorburn's *Surgery of the Spinal Cord*, pp. 77 and 111, there are similar tables for the different regions.

Localization of the Functions of the Segments of the Spinal Cord.

Segment.	*Muscles.*	*Reflex.*	*Sensation.*
Second and third cervical.	Sterno-mastoid. Trapezius. Scaleni and neck. Diaphragm.	*Hypochondrium* (?) (third to fourth cervical). Sudden inspiration produced by sudden pressure beneath the lower border of ribs.	Back of neck and of head to vertex. (Occipitalis major, occipitalis minor, auricularis magnus, superficialis colli, and supraclavicular.)
Fourth cervical.	Diaphragm. Deltoid. Biceps. Coraco-brachialis. Supinator longus. Rhomboid. Supra- and infraspinatus.	*Pupillary* (fourth cervical to second dorsal). Dilatation of the pupil produced by irritation of neck.	Neck. Shoulder, anterior surface. Outer arm. (Supraclavicular, circumflex, musculo-cutaneous or external cutaneous.)
Fifth cervical.	Deltoid. Biceps. Coraco-brachialis. Brachialis anticus. Supinator longus. Supinator brevis. Deep muscle of shoulder-blade. Rhomboid. Teres minor. Pectoralis (clavicular part). Serratus magnus.	*Scapular* (fifth cervical to first dorsal). Irritation of skin over the scapula produces contraction of scapular muscles. *Supinator longus* (fourth to fifth cervical). Tapping the tendon of the supinator longus produces flexion of forearm.	Back of shoulder and arm. Outer side of arm and forearm to wrist. (Supraclavicular, circumflex, musculo-cutaneous or external cutaneous, internal cutaneous, radial).
Sixth cervical.	Biceps. Brachialis anticus. Subscapular. Pectoralis (clavicular part). Serratus magnus. Triceps. Extensors of wrist and fingers. Pronators.	*Triceps* (sixth to seventh cervical). Tapping elbow-tendon produces extension of forearm. *Posterior wrist* (sixth to eighth cervical). Tapping tendons causes extension of hand.	Outer side and front of forearm. Back of hand, radial distribution. (Chiefly musculo-cutaneous or external cutaneous, internal cutaneous.)
Seventh cervical.	Triceps (long head). Extensors of wrists and fingers. Pronators of wrist. Flexors of wrist. Subscapular. Pectoralis (costal part). Serratus magnus. Latissimus dorsi. Teres major.	*Anterior wrist* (seventh to eighth cervical). Tapping anterior tendon causes flexion of hand. *Palmar* (seventh cervical to first dorsal). Stroking palm causes closure of fingers.	Radial distribution in the hand. Median distribution in the palm, thumb, index, and one-half middle finger. (Musculo-cutaneous or external cutaneous, internal cutaneous, radial, median.)
Eighth cervical.	Triceps (long head). Flexors of wrist and fingers. Intrinsic hand-muscles.	. . . . . .	Ulnar-area of hand, back, and palm, inner border of forearm. (Internal cutaneous, ulnar.)
First dorsal.	Extensors of thumb. Intrinsic hand-muscles. Thenar and hypothenar muscles.	. . . .	Chiefly inner side of forearm and arm to near the axilla. (Chiefly internal cutaneous and nerve of Wrisberg or lesser internal cutaneous.)
Second dorsal.	. . . . .	. . . .	Inner side of arm near and in axilla. (Intercosto-humeral.)

[1] *Amer. Journ. Med. Sci*, 1886, p. 464.

[2] *Therap. Gaz.*, 1889, p. 314.

Segment.	*Muscles.*	*Reflex.*	*Sensation.*
Second to twelfth dorsal.	Muscles of back and abdomen. Erectores spinæ.	*Epigastric* (fourth to seventh dorsal). Tickling mammary region causes retraction of the epigastrium. *Abdominal* (seventh to eleventh dorsal). Stroking side of abdomen causes retraction of belly.	Skin of chest and abdomen, in bands running around and downward, corresponding to spinal nerves. Upper gluteal region. (Intercostals and dorsal posterior nerves.)
First lumbar.	Ilio-psoas. Rectus, Sartorius.	*Cremasteric* (first to third lumbar). Stroking inner thigh causes retraction of testicle.	Skin over groin and front of scrotum. (Ilio-hypogastric, illio-inguinal.)
Second lumbar.	Ilio-psoas. Sartorius. Quadriceps femoris.	. . . .	Outer side of thigh. (Genito-crural, external cutaneous.)
Third lumbar.	Quadriceps femoris. Anterior part of biceps. Inward rotators of thigh. Abductors of thigh.	*Patellar* (third to fourth lumbar). Striking patellar tendon causes extension of leg.	Front of thigh. (Middle cutaneous, internal cutaneous, long saphenous obturator.)
Fourth lumbar.	Abductors of thigh. Adductors of thigh. Flexors of knee. Tibialis anticus. Peroneus longus.	*Gluteal* (fourth to fifth lumbar). Stroking buttock causes dimpling in fold of buttock.	Inner side of thigh, leg, and foot. (Internal cutaneous, long saphenous, obturator.)
Fifth lumbar.	Outward rotators of thigh. Flexors of knee. Flexors of ankle. Peronei. Extensors of toes.	*Achilles tendon* (fifth lumbar to first sacral). Over-extension causes rapid flexion of ankle, called ankle-clonus.	Back and outer side of leg; sole; dorsum of foot. (External popliteal, external saphenous, musculo-cutaneous, plantar.)
First and second sacral.	Flexors of ankle. Extensors of ankles. Long flexor of toes. Intrinsic foot-muscles.	*Plantar* (fifth lumbar to second sacral). Tickling sole of foot causes flexion of toes and retraction of leg.	Back and outer side of leg; sole; dorsum of foot. (Same as fifth lumbar.)
Third, fourth, and fifth sacral.	Gluteus maximus. Perineal. Muscles of bladder, rectum, and external genitals.	Vesical centres. Anal centres.	Back of thigh, anus, perineum, external genitals. (Small sciatic, pudic, inferior hemorrhoidal, inferior pudendal.)
Fifth sacral and coccygeal.	Coccygeus muscles.	.	Skin about the anus and coccyx. (Coccygeal.)

Thorburn has called especial attention to what he appropriately

FIG. 465.

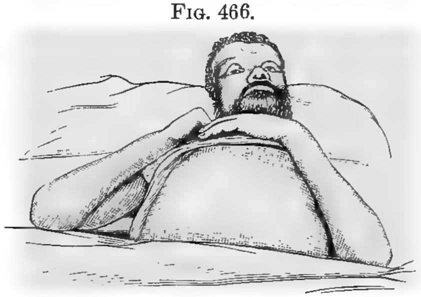
Peculiar attitude of a patient in whom the fifth cervical nerves had been crushed (Thorburn).

terms "*the fifth-root group*" of muscles, and to the almost pathognomo-

nic posture assumed by the patient who has had the fifth cervical nerve crushed and its muscles paralyzed, in contrast to the position assumed in cases of a lesion below this point. The fifth cervical nerve supplies chiefly the biceps, the brachialis anticus, the deltoid, and the supinators. If these muscles are not paralyzed—that is, if the fifth cervical nerve is uninjured and the lesion exists at a lower level, even so close as the sixth nerve—the deltoid will abduct the elbow, the infraspinatus (supplied by the fourth nerve) will rotate the humerus externally, and the biceps, brachialis anticus, and supinator longus will flex and supinate the forearms, so that the patient will lie with both his arms in the characteristic attitude shown in Fig. 465 and in the right arm in Fig. 466. That is to say, if the fracture be below the fifth cervical nerve, there will be abduction of the arm, elevation and external rotation of the humerus, with flexion of the elbow and supination of the hand.

If, however, the lesion involves the fifth cervical nerve, the deltoid being paralyzed, the elbow will lie next the body; the brachialis anticus and supinator longus being paralyzed, the forearm and hand will lie prone on the chest, as is well shown in the left arm, Fig. 466, in which the fifth cervical nerve was injured on the left side only.

FIG. 466.



An attitude in a case in which the fifth cervical nerve had been injured on the left side only (Thorburn).

At other levels than these the posture will not be so characteristic, but the site of the injury can be determined by ascertaining what muscles are paralyzed, and therefore what nerves involved. For this purpose the table (p. 815) may be consulted with advantage.

It must not be forgotten also that if the myelitis extends upward in the cord, the area of muscular paralysis will progressively increase after the accident; and it is therefore of the greatest importance to determine not only what muscles were paralyzed at first, but also, from time to time, whether the paralysis has involved other muscles from the extension of the myelitis, or whether the paralysis has disappeared in some of the muscles in case of recovery.

Secondly, the Site of the Lesion can be Determined to some Extent by the Area of the Cutaneous Anæsthesia.—In the cervical region the table of Mills (p. 815) will enable us to arrive with fair accuracy at the nerves which are involved by the area of the anæsthesia.

Starr[1] has also made a study of the area of anæsthesia in the arm corresponding to the spinal segments from the fourth cervical to the first dorsal, inclusive. Fig. 467 illustrates the different areas as nearly as has been ascertained. The Roman numerals refer, I, to the anæsthetic area of skin from lesion of the first dorsal segment, and IV to VIII to the corresponding cervical segments. His conclusions may be summarized as follows:

IV represents a part of the area of anæsthesia from lesion of the

[1] *Brain*, Part lxvii., 1894, p. 481.

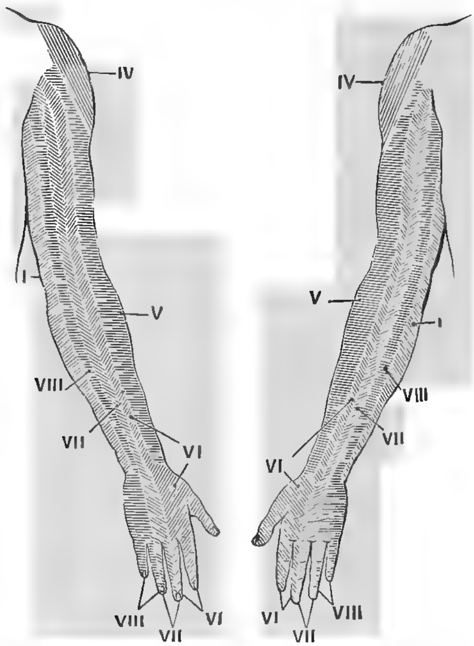
fourth cervical nerve, which, however, has not been carefully ascertained on account of the fatality of such lesions.

V (fifth cervical segment) includes the skin of the outer side of the arm and forearm from the wrist to somewhat above the deltoid insertion.

VI (sixth cervical segment) includes the radial surface of the hand from the middle line of the middle finger anteriorly and posteriorly, and also a very narrow strip up the front and back of the forearm and arm as high as the axilla.

VII (seventh cervical segment) supplies the middle of the palm and dorsum of the hand, the adjacent sides of the middle and ring finger,

Fig. 467.



Areas of anæsthesia in lesions of the cervical cord (Starr).

and a narrow strip up the forearm and arm to the axilla, both anteriorly and posteriorly.

VIII (eighth cervical segment) includes the ulnar side of the hand, the little finger, the adjacent half of the ring finger both anteriorly and posteriorly, with another strip of skin up to the axilla.

I. The area corresponding to the first dorsal segment is a narrow one on the inner side of the arm and forearm from the axilla to the wrist, but does not extend on the hand.

Mr. Thorburn states, in a general way, that the outer parts of the upper extremities correspond to the upper nerve-roots, the inner portions to the lower. In the dorsal region the area of the anæsthesia is generally almost horizontal, and if the injury be bilateral it will encircle the trunk. In determining, however, the segment of the cord which has been injured from the upper level of the anæsthesia it is very important again

to remember the fact that the foramina between the vertebræ through which the nerves pass, and the level at which the nerves emerge from the spinal cord, vary very much in level, as is shown in Fig. 456. In the upper cervical region the nerves after leaving the spinal cord descend but very little to their foramina of exit, but as we go farther down the nerves pass downward for increasing distances before they make their exit from the spinal canal. For instance, Fig. 456 shows that the tenth dorsal nerve originates opposite the body of the ninth dorsal vertebra or the eighth dorsal spine, but makes its exit below the body of the tenth dorsal vertebra. In consequence of this the upper level of the region of the cutaneous anæsthesia will be constantly below the level of the root of the nerve involved. Moreover, from the lower end of the cord, which ends at the lower border of the body of the first lumbar vertebra, a large number of nerves come off and run down in the spinal column to the lumbar and sacral foramina in a bundle of cords known as the cauda equina.

Starr[1] has made a most careful study of the condition of local anæsthesia as a guide to the diagnosis of lesions of the lower spinal cord—that is, from the second lumbar to the fifth sacral segments of the cord—and has combined the observations into two diagrams (Figs. 468 and 469), which will prove of the greatest value as a foundation for future studies. His conclusions may be summarized as follows:

FIG. 468.

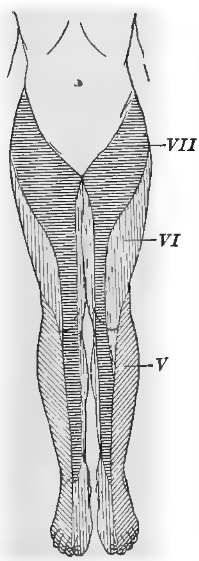
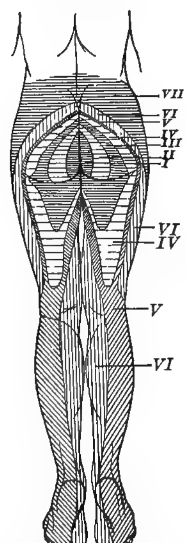


FIG. 469.



Areas of anæsthesia at various levels of the spinal cord, from sacral *V* to lumbar II: *I*, sacral V; *II*, sacral IV; *III*, sacral III; *IV*, sacral I; *V*, lumbar V; *VI*, lumbar III; *VII*, lumbar II. (after Starr).

In the spinal cord the centres of control of the bladder and rectum are always affected together, and must therefore be adjacent. Control over these sphincters is lost when the lower three sacral segments are

[1] *Amer. Journ. of the Med. Sci.*, July, 1892, p. 15.

involved, and probably the centres which control them lie in the lowest two segments. Loss of control over the sphincter ani is best determined by the introduction of the finger, which will meet with no resistance when the sphincter is paralyzed. The sphincter of the bladder is not permanently relaxed, for constant dribbling does not take place, but there is only intermittent though unconscious dribbling as soon as a few ounces of urine collect. Retention of urine is much more liable to occur when the lesion lies at a higher level. If, therefore, in a case of paraplegia the mechanism of the bladder and rectum is not interfered with, it is a proof that the lesion has not destroyed the lower sacral segments of the cord. This fact, with a careful determination of the area of the anæsthesia, may enable us to make an exact diagnosis.

Figs. 468 and 469 show the cutaneous areas of anæsthesia which are caused by lesions of the nerves indicated. Each area of anæsthesia includes the smaller ones within it. The different zones are numbered in the illustrations as follows:

I. The first zone is supplied by the fifth sacral segment, and includes the perineum, the posterior part of the scrotum in males, the vagina in females, and also the mucous membrane of the rectum.

II. The second zone, supplied by the conus medullaris and the fifth and fourth sacral segments, is heart-shaped, with the point up, and includes the entire scrotum and the posterior surface of the penis, the mucous membrane of the urethra in males, the entire genitals of the female except the outer surface of the labia majora and the mons Veneris. If the genital organs escape, the case is one of functional and not of organic paraplegia.

III. The third zone is supplied by the fifth, fourth, and third sacral segments, and involves not only the buttocks, but extends down the back of the thighs. This has been named the "saddle-shaped" area, as it coincides with that part of the body which is in contact with the saddle in riding.

IV. This corresponds to the first and second sacral segments, and is similar to the third, except that it is larger in extent.

V. The fifth zone corresponds to the fifth lumbar segment.

VI. The sixth zone corresponds to the third lumbar segment. This may hereafter be separated into two parts, corresponding to lesions of the fourth and third lumbar segments. As yet the number of recorded cases is insufficient for this distinction.

VII. The seventh zone involves the four lower lumbar segments. It will be observed that the abdominal wall is not anæsthetic in lesions of this segment. It is only when the first lumbar segment of the cord is involved that the anæsthesia extends to the abdominal wall.

Above the level of the second lumbar segment the zone of anæsthesia extends around the body in a girdle.

It is impossible, at present, by the area of anæsthesia to distinguish the lesions of that part of the cord from which the nerves of the cauda equina arise from lesions of the cauda itself. If the fracture or dislocation, however, is below the first lumbar vertebra, at which level the cord ends, the lesion must be of the cauda itself.

The muscular paralysis is very slight in lower cord lesions, being confined to the perineal muscles when the lesions are at or below the

second sacral segment. It involves the anterior and posterior tibial muscles when all the sacral segments are involved, and only involves the movement of the hip-joint when the entire lumbar region is affected. In lesions of the cauda, on the other hand, pressure on nerve-roots is often sufficient to produce widespread paralysis when sensation is but slightly affected (Starr).

It has been thought that if sensations of touch, temperature, and pain are not equally destroyed, it was an evidence of lesions of the cord as distinguished from one of the cauda, but Starr has shown that this point is not well taken.

It must not be forgotten that each sensory nerve supplies a definite area or band around the body and neck, but overlaps its neighbors above and below, so much so that each region may be said to be supplied by

FIG. 470.

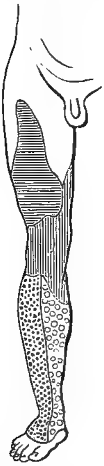


FIG. 471.

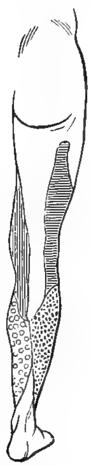


FIG. 472.

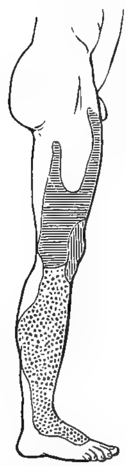
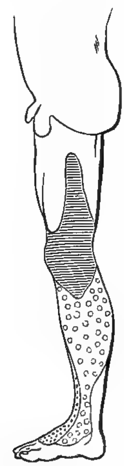


FIG. 473.



To show the presumed distribution of the areas of cutaneous sensibility in the lower extremities from the second lumbar to the first sacral segments. The area marked in *cross lines* represents the second lumbar; *vertical lines*, the third lumbar; *circles*, the fourth lumbar; *dots*, the fifth lumbar; the *plain area* below the knee, the first dorsal (Head).

two nerves. This probably accounts for the zone of paræsthesia at the border between the normal and the anæsthetic regions.

In the extremities the regions are not band-like, but irregular and distorted (Figs. 470 to 473). No such overlapping exists in the sensation of pain or heat and cold; hence the latter may sometimes be utilized even to greater advantage than the area of tactile anæsthesia in determining the level of the lesion of the cord.

In some cases, besides the fracture-dislocation of the vertebræ, there may be injury and subsequent disease of the viscera, and a knowledge of the area of cutaneous tenderness, of the areas in which consequent herpes zoster may break out, or of the analgesia, may assist us in the diagnosis of these additional lesions. (For this the reader is referred to the elaborate paper and plates by Head in *Brain*, Part lxi. pp. 1–133.)

Thirdly, the Condition of the Reflexes.—The various reflexes and their connection with the individual nerves are well shown in the table of Mills (p. 815). Their presence or absence will show whether the

segments of the cord with which they are connected are intact or have been destroyed. The same column gives in each instance the method of producing the reflex, whether by sudden irritation of the skin, by drawing a pencil or the finger-nail, etc. across it, or by tapping or stroking certain parts of the skin or striking certain tendons.

In connection with the reflexes it is of great importance to distinguish between the effects of *total* and of *partial transverse lesions* of the cord on the reflexes. Especially is this important in reference to the question of operation, since the condition of the reflexes has been held to be an index of the extent of the lesion, and especially whether it be a partial or total destruction of the spinal cord. Bastian[1] first clearly called attention to these phenomena, and Bowlby,[2] Thorburn,[3] and Herter[4] have further elucidated the facts. Their conclusion is that in *complete transverse destructive lesions* of the cord there will be complete muscular paralysis of the parts below the level of the injury, complete anæsthesia below the level of the distribution of the injured nerve, and also complete and permanent abolition of the knee-jerk and other deep reflexes on both sides; but that in *partial transverse lesions* of the cord the muscular paralysis and also the anæsthesia will be incomplete, and the deep reflexes either normal or exaggerated instead of absent. The visceral reflexes, especially those of the bladder and rectum, obey the same rule as the deep reflexes. The superficial reflexes, while they are generally absent in total destructive transverse lesions, are not always absent, especially the planter reflex. Hence it is said that if immediately after the accident the knee-jerk on both sides is absent, and remains so, operation is contraindicated.

As a general rule, there is no question that the persistent absence of the reflexes, especially of the knee-jerks, is an evidence that the cord has been so completely destroyed that it would not be wise to operate, and yet there are a few happy exceptions to the rule. Thus, Schede[5] reports the case of a man who had fallen from a height and fractured the fifth and sixth dorsal vertebræ, with complete paraplegia and anæsthesia of the lower extremities. The patellar reflexes were absent. The next day bed-sores were beginning over the gluteal region. Sixteen hours after the accident Schede operated and removed the fragments which were pressing on the cord, the dura being uninjured, but the cord being soft and fluctuating. In two days the patient's symptoms began to improve. The knee-jerks became increased, with ankle-clonus on the right side, and the superficial reflexes scarcely increased, excepting those of the foot-sole. When reported the functions of the bladder and rectum were normal, and the patient was able to walk about without support or pain. His nutrition was excellent, and two months after his discharge he was in first-rate health.

Hammond and Phelps[6] report a case of fracture of the twelfth dorsal vertebra in which "the plantar reflexes on both sides were lost; both knee-jerks were absent; the cremaster reflex was present on the right side, but lost on the left side; both abdominal reflexes were present."

[1] *Med.-Chir. Trans.*, 1890, lxxiii. 151. [2] *Ibid*, 1890, 383.
[3] *Manchester Med. Chron.*, 1892, xvi. 73, and *Surgery of the Spinal Cord.*
[4] *Journ. of Nerv. and Ment. Dis.*, June, 1891.
[5] *Annals Surg.*, Sept., 1891. [6] *Journ. Nerv. and Ment. Dis.*, 1893, xviii. 478.

There was, of course, paraplegia. The operation was done nearly two years after the injury. "A certain amount of improvement was observed the day after the operation. Tactile sense was restored on the front of the thighs. He could follow and locate a touch accurately, but all other forms of sensibility were absent. Gradually slight motion returned in the left thigh, and the right thigh became stronger than it had been. Finally, after two months he was able to walk around with the aid of crutches." Two years ago, at the Jefferson Hospital, I assisted my colleague, Prof. Forbes, in a laminectomy for an old dorso-lumbar dislocation in which the knee-jerks had been absent for eighteen months, but returned within a week after the operation.

It must be confessed, however, that while, if the rule of non-interference in cases of absent knee-jerks had been adhered to, these patients would undoubtedly have perished, yet they seem rather to be happy exceptions to the rule, and as such reinforce it. Unquestionably, a large part of Schede's success was owing to the early date of the operation—sixteen hours after the accident.

The general conclusion, therefore, is that where persistent absence of knee-jerks and other reflexes, except possibly the plantar reflex, is noted, no operation should be done, since the injury is almost certainly so profound that no good result will follow. Regeneration of the spinal cord even after incised wounds is not generally to be expected, and after its total destruction is certainly not to be hoped for. Experiment upon animals has shown that it is impossible, and clinical experience in man undoubtedly confirms it.

Besides the condition of the reflexes as determining for or against an operation, three other factors are to be considered in connection with any operation: first, the time when it should be done if done at all; secondly, the site of the lesion as influencing the decision to operate; and thirdly, the amount of interference which is allowable.

First, the Time when the Operation should be Done.—Chipault[1] has well summarized the medullary lesions after fracture of the vertebræ, and has especially insisted upon their early appearance. In all traumatisms of the cord there are three serious lesions:

(*a*) A first zone, consisting of that portion of the cord which is directly destroyed. This may be of greater or less extent. It undergoes necrosis in consequence of the destruction of the nervous elements themselves. This necrosis is immediate.

(*b*) A second zone, both above and below the first, in which the nervous elements have been injured, but not absolutely destroyed. At the end of two or three days the nervous cells are increased in size and their protoplasm has become granular, the cylinder-axes form a sort of chaplet, the myelin is broken into segments. Clinically, this beginning of degeneration in immediate juxtaposition to the injured part can be determined by noting the involvement of the motor and sensitive centres immediately above the site of the injury. If the cause of compression is removed, both cylinder-axes and myelin undergo a certain amount of regeneration by the ninth day.[2] If, however, the cause of the compression persists or the injury is sufficiently grave, the

[1] *Études de Chir. médul.*, p. 83, note.
[2] Kerestzegy and Hanns, *Beitrage f. Path. Anat.*, 1892.

destruction of the cord in this zone is permanent and is followed by sclerosis.

(c) Secondary degenerations set in at a very early period. These are caused not by the direct injury to the nervous elements, but probably by their separation from their trophic centres. These degenerations extend both above and below the site of the lesion, and begin as early as the fourth day, and continue to extend for a number of months. They follow the general rule of the Wallerian degeneration; that is to say, from the site of the lesion downward the motor fibres degenerate, and the sensory in the reverse direction. The early date at which these alterations have been well recognized, especially by experiment upon animals as well as by clinical experience, shows that if we intervene at all with hope of betterment, the earlier it is done the better. The general rule has been that of Lauenstein,[1] that if after from six to ten weeks there is incontinence of urine and fæces, with cystitis and bed-sores, little is to be hoped from Nature's efforts and an operation is justifiable.

Horsley,[2] however, is much more emphatic in his opinion, and says: "In all cases where displacement or crepitus indicates compression, and where extension directly after the accident fails to reduce the displacement, we should operate in case there are symptoms which show an interference with the functions of the cord." In view of the rare but undoubted instances of good results following early operation, the tendency of modern surgeons is to much earlier rather than later interference. The case already cited (p. 822) from Schede is an excellent illustration. Burrell[3] has analyzed 168 cases of fracture of the spine, and has not only given up his earlier plan of crushing back the fragments into place, which in the last 86 cases had given 33 per cent. of recovery as against 22 per cent. following the expectant plan in the first 82 cases, but advocates operation in all cases of fracture within the first twenty-four hours, including even those in the cervical region.

Golding Bird[4] has reported another case of operation on the second day after fracture of the eleventh and twelfth dorsal laminæ, causing almost complete paraplegia from compression of the cord by the displaced laminæ. In eighteen days the patient seemed quite well. Ridenour[5] operated one hour after fracture of the seventh and eighth dorsal with a displacement of the seventh dorsal of over one inch, the membranes being torn and the cord compressed. The operation was followed by a rapid return of the sensibility and of control over the bladder and bowels. In three months the patient could walk with the aid of a jacket. Villar[6] operated three days after a fracture of the twelfth dorsal with complete paraplegia, loss of plantar and testicular reflex, but persistence of the knee-jerks, which were subsequently lost. His patient regained control of the bladder and bowels and could move his legs, but was not able to walk. All pain had disappeared. Knox[7] operated thirty-six hours after fracture and luxation of the eleventh dorsal vertebra. On the following day sensibility had completely returned, with slight motion. Ten months later he could sit up and take some steps without support.

[1] *Centralbl. f. Chir.*, 1886, p. 888.
[2] *Brit. Med. Journ.*, Dec. 6, 1890.
[3] *Ibid.*, Oct. 2, 1894.
[4] *Ibid.*, 1891, i. 1124.
[5] *Columbus Med. Journ.*, 1891–92, x. 151.
[6] Chipault, p. 96.
[7] *Glasgow Med. Journ.*, 1893, 249.

Of course but few cases will show such marks of improvement, but had the operation been delayed in these cases it is almost certain that they would all have died from myelitis after months of suffering.

Dawbarn[1] reports the case of a young woman who had fallen four stories and fractured her spine. Complete motor paraplegia and almost complete sensory paralysis followed. Two and a half hours after the injury he did laminectomy. The eleventh and twelfth dorsal vertebræ were found crushed in several places, with two points of bone projecting into the dura and apparently into the cord. The arches were removed with the rongeur forceps. The dura was slit for four inches. Blood-clots were evacuated, and the cord was found distinctly indented, but apparently not actually lacerated, nor was there any loss of substance. On passing a probe beneath—that is, anteriorly to—the cord, resistance was met opposite the twelfth vertebra, due to the projection of a sharp spicula of bone, like the end of a lead-pencil, compressing and apparently sticking into the anterior surface of the cord. It was reached with great difficulty and removed, the arch of the vertebra being gnawed away with the rongeur forceps nearly to the body of the bone. Sharp hemorrhage from wounding of a vein followed the removal. When this was controlled by two long strips of iodoform gauze inserted under (in front of) the cord and halfway encircling it, the dura was sutured and the wound closed except for the gauze drain. A plaster-of-Paris splint was applied from the armpit to below the hips. The gauze was removed between the second and third days through a trap-door in the splint. Paralysis of the bladder and rectum continued for a month; after that, under strychnine, massage, and electricity, she improved, so that ten months after the accident she resumed her work as housemaid and cook. The right leg was slightly weaker than the left, but not sufficiently so to affect the gait, nor has the sensibility been fully regained.

Fig. 474.

Backward displacement of the fractured lamina of the eleventh dorsal vertebra, compressing the cord (Chipault).

The result in this case seems to be attributable, as the author believes (an opinion in which I fully concur), to the immediate operation. Had such fragments of bone been allowed to press upon the dura and cord for any length of time, unquestionably myelitis and meningitis would have followed, and the patient's health, if not her life, would have been sacrificed.

Chipault[2] has recently reported a similar noteworthy case of fracture of the eleventh dorsal, with displacement backward of a bony semicircular fragment compressing the cord, in which recovery followed opera-

[1] *Annals of Surg.*, Jan., 1895, p. 46.
[2] *La Nouvelle Iconographie de la Salpêtrière*, 1894.

tion (Fig. 474). The young man fell from a roof. There was great pain at the eleventh dorsal spine, without any deformity. The left leg was paralyzed, including the muscles of the left buttock, but the left sartorius was only paretic. There were anæsthesia and analgesia (without thermic anæsthesia) of the penis, scrotum (partial), the perineum, the buttock (partial), posterior surface of the right thigh in a thin band, and all the parts below the knee, with slight anæsthesia of the left foot. The cremaster reflexes were preserved, the knee-jerks slight, the plantar absent. On the eleventh day laminectomy was done. Improvement began at once, and a year and a half later he resumed an active and laborious occupation, carrying on his back very heavy weights, and his lumbar suppleness was normal. The reflexes were normal.

Besides this, it must be remembered that while the early results of operation may be a doubtful improvement, yet gradually, after, it may be, a year, the improvement may be very marked. Hence we should not despair of any case until at least a year after operation, and meantime not only should all the usual hygienic methods be employed, such as good diet, change of air, bathing, and attention to the bladder and bowels, but also massage of the paralyzed extremities, with galvanism or faradism as may be required, should be persistently employed.

Secondly, the Site of the Lesion as Influencing the Decision to Operate.— In general it may be said that the higher the lesion the less favorable the prognosis, and therefore the less should we be disposed to interfere. Although there are a few cases reported not only of operative recovery, but also of good recovery of function, following operations in the upper dorsal region, yet we may say in general that operation above the seventh dorsal will rarely be of value, and should only be undertaken when the symptoms and collateral conditions are entirely favorable. In the lower dorsal and the lumbar regions the prognosis is considerably more favorable, provided that evidences of severe lesions of the cord are absent, and below the second lumbar it is almost a rule that operation should be undertaken. The cord, as is well known, terminates at the lower border of the first lumbar vertebra. From that point to the end of the sacrum we have a leash of nerves known as the cauda equina, and an injury to these nerves is really an injury to peripheral nerves, and not at all an injury of the cord. In such cases, even at a late period, operations can be undertaken with advantage.

Here again, however, the rule should be for early interference rather than late, so that the source of compression or laceration may be removed and any later additional compression from callus may be avoided. If the nerves of the cauda equina are divided, they should be sutured precisely as any other peripheral nerve, and the far greater success of primary suture over secondary is an additional argument in favor of early operation, which should be immediate if the evidence of laceration or compression is positive, or within a few days afterward, or at least so soon as the shock of the injury has passed, when time has been given to show that it is not merely a contusion of the nerves. The same rule would apply also to all lesions of the nerve-roots at other points in the cord. They are peripheral nerves the moment they leave the spinal cord.

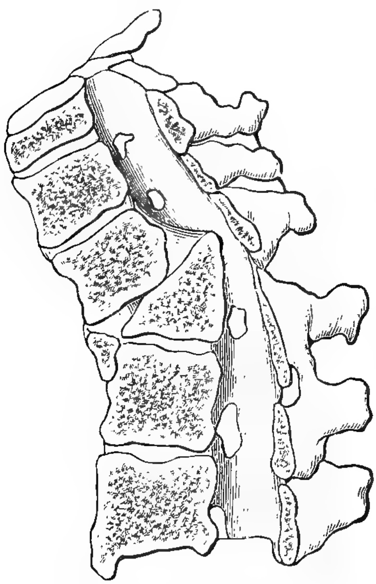
Of course, if the fracture is limited to the arches with displacement

such as to cause pressure on the cord, we should operate in any region of the spine.

Thirdly, the Amount of Interference which is Allowable.—In very many cases surgeons have contented themselves with the more or less complete removal of the posterior arches. If the fracture is limited to these, this is quite sufficient, but if the fracture or fracture-dislocation involve the bodies of the vertebræ, there is not uncommonly such a displacement of a portion of the body of the vertebra as to produce two causes of compression—one posteriorly in the arches, the other, and more frequent and serious, anteriorly in the bodies of the vertebræ (Fig. 475).

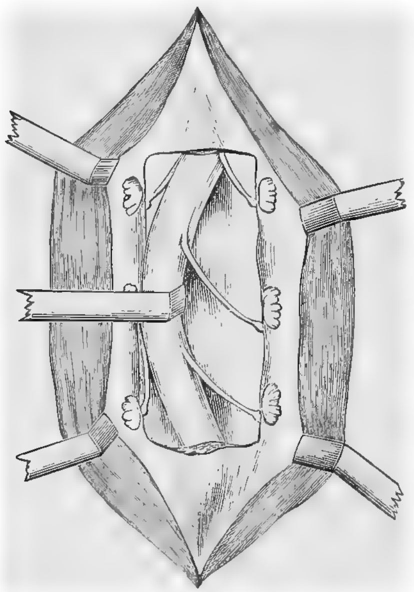
It is not good surgery to remove only one source of compression and leave the other, and, inasmuch as the cord can be drawn to one side to a

FIG. 475.



Old dorso-lumbar fracture, with permanent displacement (Chipault).

FIG. 476.



Lateral displacement of the cord to expose the posterior surface of the bodies of the vertebræ (Chipault).

very considerable extent (Fig. 476), it is much better to do this and to remove the projecting portion of the body of the vertebræ. This can be accomplished by the careful use of a chisel, gouge, or curette. The degree to which the cord can be displaced laterally is very considerable, and if traction be made on one side and then upon the other with an aneurysm needle or with a narrow blunt retractor, the posterior surface of the bodies of the vertebræ can be reached. Just how far such operative procedures on the bodies of the vertebræ may be justifiable and successful we are at present not in a position to express a positive opinion.

The technique of the operation is described on p. 858.

Results of Operation.—After all, the question as to whether an opera-

tion should be done or not depends upon the results obtained. Gurlt has recorded 217 deaths out of a total of 270 fractures treated without operation (a mortality of 80 per cent.), and it must be confessed that in many of the 20 per cent. who recovered life was scarcely worth the living. On the other hand, Thorburn has collected 61 cases of operation of which 35 died, or only 57 per cent. In some of those who recovered the recovery was almost complete, while in those who still suffered from paraplegia the improvement in the bed-sores, the regain of control over the vesical and anal sphincters, made life much more bearable, though still depressing. Chipault has tabulated 104 cases of operations of all degrees of severity—chiefly gunshot fractures, however—from 1750 to 1891. Of these, the result was unknown in 9, leaving 95 terminated cases: 83 of these cases were operated on prior to 1878, in the days before antiseptic surgery. With modern methods the results would undoubtedly have been better. Yet of the 95 cases only 38 died, a percentage of deaths of 40 per cent. and recoveries 60 per cent. Again, Lloyd[1] has collected 103 traumatic cases operated on, with 58 deaths (mortality 57.3 per cent.); of those treated antiseptically, 50 per cent. died; of the non-antiseptic cases, 63 per cent. died; of the latter only 1 was cured (2 per cent.), and 7 recovered partially (16 per cent.); of the former, 4 were cured (6 per cent.), and 15 recovered partially (25 per cent.). With such statistics before us it is impossible to draw any other conclusion than that operation is advisable "in case extension directly after the accident fails to reduce the deformity" (Horsley). Of course the limitations arising from the time that has elapsed since the accident, the region involved, and the severity of the lesion must be given due weight in reaching a conclusion in any given case.

In an accident, therefore, of such gravity, followed by such an immense percentage of deaths if no operation be done, it would seem to be advisable with our present experience, in all suitable cases, to give patients the real though often desperate chance that operation affords, and that the operation should be done at a much earlier period and more thoroughly than has hitherto been the rule.

The far greater success which has followed operation in the region of the cauda equina justifies the conclusion of Chipault,[2] that—

"(*a*) In case of lumbar or sacral fracture, with permanent and irreducible displacement of the bony fragments, we should interfere at once.

"(*b*) In case of fracture which is reduced either spontaneously or by surgical manipulations, wait. If the course of the case is toward recovery, wait; if the case remains stationery, intervention is justified toward the end of the first month—not earlier, since functional restoration may not begin till toward this period; not much later, since incurable spinal degenerations may be established."

Treatment.—The question of operation in various regions has already been considered while treating of the symptoms and the diagnosis. The technique of the operation will be found on p. 858. Only the non-operative portion of the treatment, therefore, remains to be considered.

The transportation and immediate care of the patient are important. Every precaution should be observed to prevent further laceration of the

[1] *Amer. Journ. Med. Sci.*, July, 1891, 25.

[2] *Études de Chir. médul.*, p. 71.

cord, as well as to prevent severe pain, by handling him with the utmost gentleness. In placing him upon a stretcher or the bed, especially if the fracture-dislocation be in the cervical region, the head and neck should not be flexed or rotated, and they should be immobilized by cushions or pillows or sand-pillows placed on each side of the head. Cautious traction under an anæsthetic in most cases may be made to reduce the deformity if it exists. Even in cases with imperceptible pulse and stertorous breathing such reduction may be followed by partial or even most complete recovery. To be successful no time should be lost, but the reduction should be made within the first few hours or days after the accident. If in the dorsal or lumbar region, after the deformity has been reduced a plaster-of-Paris jacket may be used with advantage to retain the fragments in place, together with extension to the head or legs, or both, by means of weights and pulleys. In applying the jacket the patient should be suspended (as in applying the plaster jacket in Pott's disease), but the surgeon should be on the watch for any unfavorable symptoms, and an anæsthetic should never be employed. Instead of being suspended, he may be placed between two tables, which are then gradually separated to a sufficient extent. In the space between the separated tables the jacket can be applied while the patient all the time remains in the horizontal position. The use of the plaster jacket has been followed by paraplegia or excessive pain, which disappeared after its removal. The effects of the use of the jacket must, therefore, be carefully watched.

The subsequent treatment will consist in the suitable administration of opiates for pain, careful regulation of the diet, attention to the bladder and bowels, scrupulous avoidance (if possible) of bed-sores, and later in the use of electricity, massage, douches, passive exercise, and, still later, the active use of the limbs as the patient regains control over them, if indeed he ever do so.

Gunshot Fractures of the Spine.

Gunshot wounds are received, of course, in the majority of cases, during war, though one sees them occasionally in what may be called by courtesy, in such instances, civil practice. They are not uncommonly immediately fatal. In the cervical region this may follow from a wound so high as to produce paralysis of respiration. The vertebral artery also may be wounded, and the patient die from either primary or secondary hemorrhage. If the ball penetrate the chest or abdomen or pelvis, fatal lesions may occur by perforation either of the heart or the aorta, or by penetrating wound of the viscera, such as the bladder or intestines, followed by extravasation and peritonitis. Even should death not occur from such complications, it very frequently follows, as in ordinary fractures of the spine, from exhaustion, bed-sores, pyæmia, or septic pneumonia, or, on the other hand, from myelitis and osteomyelitis, the direct result of injury to the cord or the vertebræ. Not uncommonly necrosis of the vertebræ occurs. The most remarkable instance of this that I have ever seen, especially as the patient recovered so well, is reported by Mitchell, Morehouse, and Keen.[1] A young man, aged twenty, was

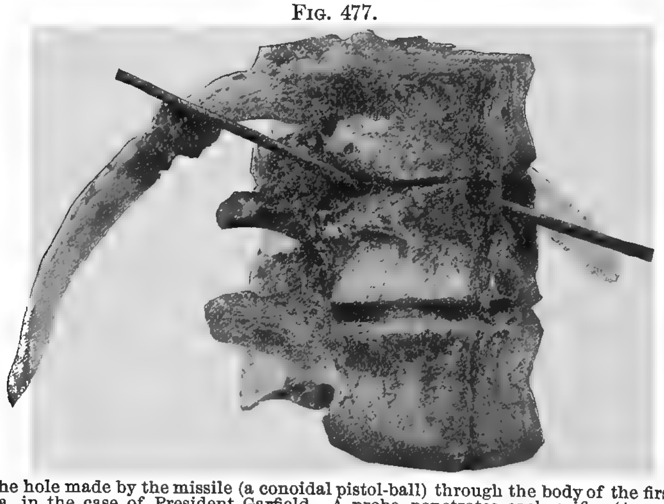
[1] *Gunshot Wounds and other Injuries of Nerves*, p. 28.

wounded in the battle of Gettysburg, July 2, 1863, by a minié-ball, which wounded the upper lip and the teeth and penetrated the body of the third cervical vertebra, where it lodged. A month later the ball was located by Nélaton's probe and was removed. The man was paralyzed for a time in all four extremities, but rapidly recovered from the paralysis, and was placed on duty as a hospital attendant. Nearly a year later a large part of the body of the third cervical vertebra was spontaneously discharged through the pharynx. The specimen showed the anterior half of the transverse process of the vertebra, including the anterior border of the vertebral foramen.[1] No injury, however, to the vertebral artery was discovered. Eight years later the man was alive, and a pension examiner reported that the right side of his tongue was distorted, leaving his speech affected, the right side of the throat contracted, his right shoulder and arm atrophied and partially useless.

The fatality of such accidents is, of course, very great. During our late Civil War there were 642 cases of gunshot wounds of the spine reported, of which 349, or 55 per cent., proved fatal: many of them, of course, did not involve the cord. The mortality in the cervical region was 70 per cent., in the dorsal 63.5 per cent., and in the lumbar 45.5 per cent.

The **diagnosis** of such injuries is, of course, easy as to the fact, but as to the amount of injury is often very difficult. A disinfected finger can sometimes be introduced, and will give us important information. If not, a very carefully-introduced disinfected probe may be also valuable,

FIG. 477.



Showing the hole made by the missile (a conoidal pistol-ball) through the body of the first lumbar vertebra, in the case of President Garfield. A probe penetrates each orifice (Army Medical Museum specimen).

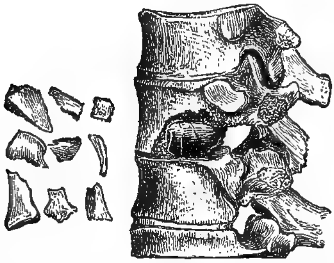
but, as a rule, neither of these means, especially the probe, is necessary, and usually is inadvisable, inasmuch as the symptoms will generally give us information of what injury has been inflicted upon deeper structures which can be reached neither by the finger nor by the probe. The well-known case of President Garfield (Fig. 477) is an illustration of how

[1] By an error in print this was described as the "carotid" instead of the "vertebral" foramen.

difficult it may sometimes be to come to a proper conclusion. (Figs. 478 to 481, from the Army Medical Museum, illustrate various forms of gunshot wounds of the spine.)

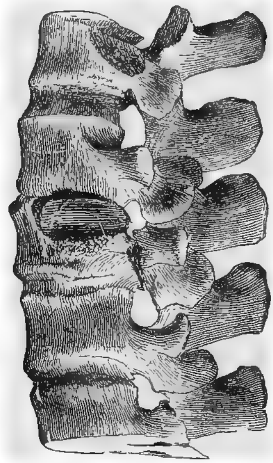
Treatment.—In many cases of gunshot wounds of the spine other lesions of a probably fatal character will most likely forbid any interference; but if this is not the case, the surgeon should not hesitate to operate in favorable cases. The statistics of Chipault (p. 169) very clearly indicate its advisability. Of course the surgeon must carefully observe antiseptic precautions, and no interference with the wound, either by the finger or the probe or any other instrument whatever, should be allowed, unless both the wound, the hand, and the instrument have been most carefully disinfected. If the wound involves the vertebræ alone, and not the cord, it would

Fig. 478.



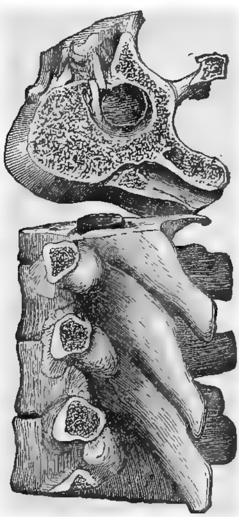
Gunshot fracture of the body and left transverse process of the ninth dorsal vertebra. The missile and nine fragments of the bone are also shown (specimen 5738, Army Medical Museum).

Fig. 479.



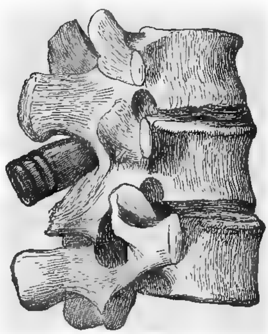
Gunshot fracture of the third lumbar vertebra, with the missile attached (specimen 2531, Section I., Army Medical Museum).

Fig. 480.



The fifth, sixth, seventh, and eighth dorsal vertebræ, with the body, etc. of the fifth divided horizontally, and a conoidal musket-ball (also divided) lodged in the spinal canal (specimen 3894, Section I., Army Medical Museum).

Fig. 481.



Gunshot fracture of the spinous process of the second lumbar vertebra, with the missile impacted between the laminæ of the first and second (specimen 611, Section I., Army Medical Museum).

always be proper after disinfection to make a suitable incision, to remove all loose spiculæ of bone, and to introduce a small drain of iodoform gauze.

Gunshot wounds involving the cord are divided by Vincent[1] into three classes: First, those in which the cord is compressed by extravasation of blood, fragments of bone, or by the projectile itself lying outside of the medulla or canal. It is evident in such cases that operation would be proper, since we may be able to remove the source of the compression, and if so at least do no harm and with a possible prospect of improvement.

Second, those in which the projectile in passing through the spine has injured the cord. As an exact diagnosis of the amount of injury cannot be made without an operation, and as an operation will not likely inflict serious additional injury upon the patient, and may place the wound in a more favorable condition for cure, it would be proper in favorable cases—which are unfortunately rare—to explore, unless other fatal and especially visceral lesions are present. If, however, the evidence points to an extensive and perhaps total transverse lesion of the cord, it would be better, in my opinion, to refrain from any operation.

Third: the cases in which the projectile has lodged in the spinal canal. An operation then should be done, as it is almost absolutely certain that the wound will be followed by meningitis and myelitis, and death be brought about by exhaustion, bed-sores, and cystitis. The large mortality already alluded to in injuries of the spine—a percentage which would be very much greater were it limited to those in which the spinal cord is involved—is at once an incentive to operation, which may possibly relieve, but at the same time a warning that the great majority of cases will die. The surgeon, therefore, should not be led to make any other than the gravest prognosis, and should only operate in cases in which the conditions are favorable.

Dislocations of the Spine.

While very frequently the violence which is sufficient to produce dislocation also produces fracture, yet autopsies have shown that there is a large proportion of pure dislocations. Thus, Ashhurst reports of 394 cases, 124 with pure dislocations. The diagnosis of dislocation from fracture, except as determined by operation or by autopsy, is generally doubtful.

The upper vertebra is always spoken of as the dislocated vertebra. Dislocations increase in frequency from the lower to the upper part of the spinal column. The great majority are in the cervical region, where the bodies of the vertebræ are small and the interlocking of the vertebræ at the articular processes much less firm than lower down. A few are reported in the dorsal region. In the lumbar region they are extremely rare. The occiput is occasionally dislocated from the atlas, and the atlas more frequently from the axis. In the remaining cervical vertebræ dislocation is not uncommon, the fifth cervical being the one most frequently dislocated.

[1] *Revue de Chir.*, Feb., 1892. I have somewhat modified his conclusions to accord with my own more conservative opinions as to operative interference.

As a rule, the dislocation is bilateral, but there are on record a considerable number of cases of undoubted unilateral dislocation. They may be complete or incomplete according to the degree of dislocation of the articulating surfaces.

The **causes** of dislocation are either severe blows, a heavy weight falling on the head, or a patient may strike head foremost, as in falls, somersaults, or occasionally in bathing. A few have resulted from muscular action in turning the head. In judicial hanging dislocation, as a fact, I believe, has never been established; but in suicidal hanging, with rotation of the body as the patient swings himself off, instead of dropping vertically, as in judicial hanging, it is sometimes seen. Occasionally also dislocations occur spontaneously from disease.

Symptoms.—These are much the same as in fracture. There may be no crepitus discovered even in fracture, since it is not allowable to institute free manipulation, lest further harm be done to the cord, and for the same reason the determination of preternatural mobility is often impossible. Hence the diagnosis is established rather by probability based upon the rigidity of the neck, its curve in the position of wryneck, the twist in the neck turning the face to the opposite side in unilateral dislocation, the recognition by palpation of the mechanical abnormal relation of the spinous and transverse processes, and the absence of easily-determined crepitus and abnormal mobility.

There is usually considerable deformity. The spinous processes, instead of being in their normal relations, are recognized in an abnormal position. There may, however, be but little, or in some cases no, recognizable deformity. In the cervical region, if the dislocation be high up, there will be great dyspnœa, or even death almost instantaneously in case the respiratory centre in the medulla oblongata is involved. When the dislocation is above the upper origin of the phrenic nerve (the fourth cervical), it will produce paralysis of the diaphragm and of the intercostal muscles, and speedy death from asphyxia; but if below the fourth cervical, life is prolonged by the uninterrupted activity of the diaphragm. If the finger is introduced into the pharynx, the abnormal position of the bodies of the vertebræ can be recognized, and also in not a few cases it can be ascertained by the eye. The head will be rigidly held in position, and the posture is often significant, the head being thrust forward. If it involves the brachial plexus, the arms as well as the legs will be paralyzed; if below the brachial plexus, only the lower extremities, and of course more or less of the trunk, will be paralyzed. Motion, as a rule, is more interfered with than sensation. In a good many cases the symptoms will not point conclusively to the differential diagnosis between pure dislocations and a so-called fracture-dislocation in which the two lesions are combined.

Treatment.—The first question that naturally arises is that of transportation of the patient to his home or to a hospital. If the dislocation be cervical, the head must be steadied with great care, and especially should be prevented from falling forward, lest instantaneous death should take place.

The method for the reduction of dislocations is by certain manœuvres in connection with traction. A few instances are on record of spontaneous reduction having taken place. This is most apt to occur during

sound sleep, when the muscles are entirely relaxed. In a remarkable case reported by Blasius[1] of unilateral dislocation of the third cervical vertebra, after an attempt to reduce the dislocation by traction on the head had failed, on the way home the child leaned his head and shoulders against a wall and pressed forcibly against the opposite convex side of his neck, and instantly reduced the dislocation.

Usually, however, such simple means do not avail. The ordinary method by traction and rotation is the one which has been, thus far, generally adopted by surgeons. In case the dislocation is a high cervical one, before it is attempted the patient and the family should be informed that there is a possibility of immediate death, although in Ashhurst's paper there is no instance recorded of such an accident. The amount of traction which has been applied is very considerable. In some cases all the force that the surgeon has been able to apply by holding the chin and occiput in his two hands while counter-traction is made either through the legs, or in cervical dislocations through the arms, has been employed. Several times also, when the first or second attempt has failed, success has attended a later attempt. Even if considerable time has elapsed since the accident, we should not despair of effecting a reduction, inasmuch as cases of four and even seven months are on record in which the attempt has been successful.

Walton[2] has described a new method of reducing cervical dislocations which seems well worthy of trial. It is especially adapted to unilateral dislocations, but may be used for reduction of a bilateral dislocation, first upon one side and then upon the other. He advises that no extension of the head shall be made, but that the manœuvre shall be as follows: "Perform retrolateral flexion toward the side toward which the face is turned by the dislocation; then rotate back into place." Once the reduction is effected, the head should be made immobile by sand-bags on each side of it, by a plaster cast reinforced by strips of tin imbedded in it, or by traction with a weight and pulley and the ordinary strap applied to the chin and occiput. The patient should be fed by means of a bent glass tube. The condition of the bladder and the bowels should be very carefully watched. In case the reduction has not been effected at once, the prevention of bed-sores should be one of the chief objects of the surgeon, as in cases of fracture. It must be remembered also that if paralysis exist the greatest gentleness and care should be used in the introduction of a catheter, inasmuch as, the urethra having lost its natural sensitiveness, serious injury may be inflicted upon it, unless this injunction is remembered, without the patient's warning the surgeon, as he will feel no pain.

Even if reduction cannot be effected, the parts should be immobilized to promote the formation of such adhesions as will restore the firmness of the spine. If traumatic myelitis arise or pulmonary congestion follow, the usual treatment for such conditions must be instituted.

Unilateral Dislocations.—These occur only in the cervical region. They have been caused by abrupt turning of the head to one side, by falls, or by heavy bodies falling upon the head. Beach[3] has suggested

[1] "Die traumat. Wirbelverrenk.," *Vierteljahresschr. f. prakt. Heilkunde*, 1869, vol. 104, p. 114.

[2] *Boston Med. and Surg. Journ.*, Dec. 7, 1893.

[3] *Ibid.*

that the ligamenta subflava play an important rôle in firmly locking the vertebræ in consequence of their elasticity.

Symptoms.—The head is turned to one side and held in the position of torticollis, the sterno-cleido-mastoid, however, on the side which would produce such a wry-neck being relaxed, while it is stretched upon the other side of the neck. In incomplete unilateral dislocation, while the face is rotated sidewise, the head is not held in the position of torticollis. In either case, however, the head will be immovable. The transverse process can sometimes be felt out of place. The veins are prominent and the respiration is difficult, especially if there be much pressure upon the cord. Not uncommonly there will be dysphagia. The eyes also are very prominent. Paralysis may be present or absent, and may come on early or late. Not uncommonly a sensation of pins and needles is experienced in the extremities.

The **prognosis** of unilateral dislocation is much more favorable than that of bilateral. It is not seldom apt to undergo spontaneous reduction in sleep. The mode of reduction suggested by Walton is the best one which has thus far been proposed. The same precautions should be used for a reasonable time as after bilateral dislocations. Thorburn[1] has collected 41 cases of unilateral dislocation in which reduction was apparently effected in 35, but he relates a case of apparently successful reduction, attended by a distinct snap, in which the autopsy three years later showed that the reduction was only apparent. Such a case throws much doubt on many of the similar cases.

Dislocation of the Occipital Bone from the Atlas.

This is excessively rare; Stimson states that there are, however, three undoubted cases. The diagnosis will be made chiefly by the deformity, the chin sinking upon the chest, difficult speech, and dysphagia, and the symptoms of compression of the medulla. Death is almost always sudden from the lesion of the respiratory centre.

Treatment.—If the survival of the patient allows of any treatment, it should be by careful reduction, by traction and manipulation, the head and neck being steadied by sand-bags, plaster of Paris, or other similar means after reduction is accomplished.

Dislocation of the Atlas from the Axis.

This is not very uncommon. It is caused by falls, by sudden and violent rotation of the head, and by suicidal hanging. The odontoid or the check ligaments are ruptured. Death usually occurs instantly from the pressure of the odontoid process on the medulla. The lesions found by autopsy are three—fracture of the odontoid, rupture of the odontoid ligament, or slipping of the odontoid from within the grasp of the ligament.

Symptoms.—The chin is commonly flexed upon the chest. The spine of the axis is very prominent posteriorly, and the anterior arch of the atlas is perceived in the pharynx. There will be severe pain, and either mobility or rigidity of the head. The spinal symptoms will depend upon the degree of the compression. If not immediate, death

[1] *Brit. Med. Journ.*, Oct. 27, 1894.

may occur at a later period from increase of the displacement in consequence of movements of the patient.

The **treatment** is the same as in the preceding dislocation.

Dislocation of the Lower Five Cervical Vertebræ.

Dislocation of these vertebræ is frequent, and not uncommonly is combined with fracture. Dislocation of the fifth cervical is the most frequent.

The varieties may be disastasis of the vertebræ; bilateral dislocation, either forward, backward, or in opposite directions of the two sides; or unilateral, forward. The bilateral and unilateral forward are the commonest.

Symptoms of the Unilateral Dislocation Forward.—The position of the head varies, but generally the face is turned away from the dislocation. There will be a prominence on the dislocated side, the muscles on that side being usually put on the stretch; those upon the opposite side are usually relaxed, though they may be contracted. The spinous processes are deviated, but in the vertebra most frequently dislocated—the fifth—this cannot easily be determined. There may be deformity in the pharynx. The spinal symptoms will depend upon the amount of the lesion of the cord, there being paralysis of the muscles of all four extremities and the trunk, excepting the diaphragm if the lesion is below the fourth cervical, together with, of course, local pain and tenderness. The peculiar posture noted in fracture of the fifth-root group may assist us in diagnosticating the lesion more accurately.

Fig. 482.

Ayres' case of bilateral dislocation forward of the fifth cervical vertebra (Stimson).

Symptoms of Bilateral Dislocation Forward.—The head is bent forward or back, or backward and to one side, and there may be marked projection of the entire larynx (Fig. 482). The head is held fixed and all motion is painful. The irregularity of the transverse processes can be followed, and there may be a pharyngeal tumor. The symptoms from the lesion of the cord will vary, as in the preceding dislocation.

The **prognosis** is unfavorable, and the **treatment** is by manipulation and traction, especially by Walton's method.

Dislocations in the Dorsal and Lumbar Regions.

These are very rare. They occur most frequently between the twelfth dorsal and first lumbar, probably, as suggested by Bell, in consequence of this being the point of junction of the rigid dorsal and mobile lumbar vertebræ. It is especially in the dorsal and lumbar region that the diag-

nosis from fracture is so doubtful, or, in many cases, if not in the majority, practically impossible. The cause is usually violence inflicted either by falls or blows.

Symptoms.—There is apt to be angular deformity of the spine quite appreciable to the touch. There is pain, especially from pressure on the spinal nerves, with paralysis more or less complete of the parts below the dislocation, and irregular hyperæsthesia just above the paralyzed parts. A low temperature, even to 92° or 93° F., is not uncommon.

Treatment.—Great care should be used in the transportation of the patient, lest further injury be inflicted upon the cord. He should be lifted with gentleness and placed upon a firm, good mattress while being taken to his home or a hospital. The reduction is best made by firm traction by means of the arms and head upward and the lower extremities downward, the patient being flat on his back, and best on the floor, in order to give ready access to his body.

Should one attempt fail, repeated attempts may be made at a later time. No time should be lost after the surgeon is called to the patient, since the persistence of the dislocation, especially if there be evidences of pressure on the nerves or the cord, will render later attempts much less beneficial. If reduction cannot be effected, the trunk should be immobilized by means of a plaster bandage, and the lungs should be carefully watched, less hypostatic congestion and pneumonia should follow. The same care to avoid bed-sores and in the use of a catheter before alluded to should be exercised. Possibly, even for the first two or three days, Stimson suggests that it would be well to remove the urine by aspiration above the pubes rather than by catheterization. Harrison[1] has suggested a perineal incision with permanent antiseptic drainage of the bladder. Operative procedures may be of benefit in these dislocations. Stimson advocates refraining from operation until the recovery of the soft parts, but as the injury to the cord and its continued compression by the dislocation are the chief dangers, it seems to me that early rather than late operation would be wiser.

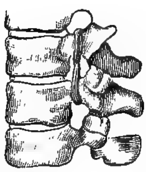
Dundore[2] reports the case of a young man, aged twenty-one, who had partial dislocation of the ninth dorsal vertebra from a fall of top rock in a mine. Three months after the accident he came under Dundore's care, who found his weight was but 98 pounds, as contrasted with 145 pounds before the accident. There was entire loss of motion in the lower extremities, excepting very slight movement in the left toes; sensation was almost lost up to the hips, above that point was normal. There was complete retention of urine, with severe cystitis. His temperature ran up to 101° to 103° F. in the evening. In two months attention to his general condition had improved him so much that he weighed 125 pounds, and his temperature ranged between 99° and 100° F. The cystitis also had greatly improved, and he was able with some effort to urinate without the aid of a catheter. Sensation and motion both were very slightly improved. He was then trephined, the eighth and ninth dorsal laminæ being removed. The cord was found to be compressed and greatly congested, but there was no evidence of laceration. He was no better in the next five or six weeks, but then im-

[1] *Liverpool Med.-Chir. Journ.*, July, 1888.
[2] *Med. News*, Nov. 24, 1894.

provement became much more rapid, and with massage, electricity, etc. in three months he was discharged from the hospital on crutches, and six months later "walked very well and without effort." He carried a cane, but this seemed to be more from habit than from necessity. His weight had increased to 150 pounds. He drove a wagon for a living, and showed very little loss of motion in the lower extremities.

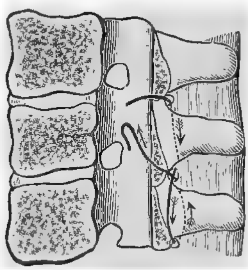
WIRING THE VERTEBRÆ.—In 1888, Wilkins[1] reported a case in which a hernia between the twelfth dorsal and first lumbar vertebræ took place. He fastened the two vertebræ together by carbolized silk ligatures passing through the intervertebral notches (Fig. 483) the day after its birth, and the child was well in a few days. Hadra of Texas[2] in a case of fracture of the sixth cervical vertebra, which was dislocated forward and rotated on its vertical axis to the right, proposed that the spinous processes of the vertebræ should be wired as a means of immobilization both in such a fracture and in Pott's disease (Figs. 484, 485). In the patient upon whom he did this operation paralysis followed at a later period from bending his neck too far. The head and neck were

FIG. 483.



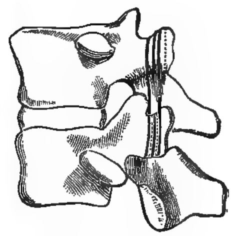
Wilkins's sutures of the vertebral arches through the intervertebral foramina (Chipault).

FIG. 484.



Interspinous suture of Hadra (Chipault).

FIG. 485.



Intertransverse suture of Hadra (Chipault).

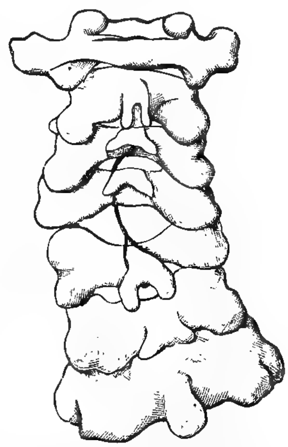
turned to the right, the right hand was numb, the right arm weak, girdle-pains existed around the upper abdomen, and want of control of the bladder and slight priapism existed. Even ten months after the accident crepitus was still perceptible. The vertebral canal was not opened, but the sixth and seventh spines were wired together by silver wire in a figure of 8. After some weeks, the wire having become loose, it was removed and a new one put in place. I saw this patient in the early part of 1892. He had then entirely recovered from his paralysis, but there was marked inability to move his head well. He required constantly a thick high circular collar, somewhat resembling an Elizabethan ruff, around his neck to support his head, and was disabled practically from any form of labor. His disability he rendered a means of support by exhibiting himself in a dime museum.

Chipault[3] has reported a very remarkable case of unilateral elongation of the roots of the right fourth and fifth cervical nerves from antero-lateral subluxation of the fourth cervical vertebra from a fall from a tree, which was cured by wiring the spines. The luxation caused immediate

[1] *St. Louis Med. and Surg. Journ.*, June, 1888.
[2] *Phila. Med. Times and Register*, May 23, 1891.
[3] *La Nouvelle Iconographie de la Salpêtrière*, 1894.

paralysis of all four limbs. In some weeks the paralysis disappeared, but the patient's head was inclined to the right, and the paralysis of the left arm and shoulder, which was slight in the morning, in an hour after assuming the erect posture became greatly increased, and remained so during the rest of the day. The temperature and the sensibility of the arm were normal in the morning, but on rising he suffered from serious numbness and a feeling of cold, which corresponded to a real local fall of temperature; the radial pulse became feeble, and the inclination of the head was greatly increased. By touch both in the pharynx and the neck the diagnosis of subluxation was established. The clavicular portion of the left sterno-mastoid, the clavicular portion of the great pectoral, the median portion of the serratus magnus, the supra- and infraspinatus, the deltoid, the biceps, and, to some extent, the supinators, were all atrophied and paralyzed without showing the reactions of degeneration. The reflexes were all normal, as were the functions of the right arm, both legs, and the bladder and rectum. The primary paralysis Chipault attributed to the original contusion or commotion of the cord; the later symptoms, to an elongation of the fourth and fifth cervical roots of the right side from the subluxation of the fourth cervical vertebra. A year after the accident he exposed the cervical arches, verified the diagnosis, reduced the luxation "to a great extent" by forcible traction on the head, wired the third spinous process to the fifth to force the fourth spine to the right (Fig. 486) by five or six turns of silver wire, sutured the periosteum, muscles, and skin, and applied plaster of Paris, which the patient wore for a month. The head became almost perfectly straight, the obliquity did not increase on rising, and the pharyngeal displacement had disappeared. At the end of eighteen months he had all movements of the head except flexion, which was arrested at half the normal degree. In all other respects motion and sensation were entirely normal, and he had resumed his ordinary occupation and amusements, including the bicycle.

FIG. 486.



Wiring the third cervical spine to the fifth for subluxation of the fourth cervical vertebra (Chipault).

ACUTE TRAUMATIC MENINGITIS.

Acute traumatic meningitis frequently occurs after incised wounds involving the meninges, gunshot wounds, compound fractures, and other similar injuries of the spine. It is not infrequent even in closed fractures, in dislocations, and in concussion of the spine from sprains and wrenches. In the traumatic form it is more apt to consist of a combination of pachymeningitis (inflammation of the dura) and leptomeningitis (inflammation of the pia arachnoid) than either one alone. As a rule, in a short time pus accumulates either between the dura and the bone (extradural) or between the dura and the cord (subdural). The membranes become thickened, especially if pachymeningitis is the pre-

dominant form. The fatty tissue outside the dura is absorbed, and the dura may become adherent either to the bone or to the cord unless separated from either by pus. Myelitis is often added to the meningitis. The cord becomes injected and softened, with abundant leucocytes, and the nerve-roots are swollen and inflamed.

Symptoms.—The onset is sometimes very sudden; at other times, though speedy, it is more gradual. There may be a chill, vomiting, and sometimes a sudden and marked rise in temperature, though it may not exceed in milder cases 102° F. The pulse is full and rapid, and the respiration shallow and hurried. There is intense pain in the back, which is aggravated by motion, with pains which are apt to be burning and shooting excentrically, in consequence of the involvement of the nerve-roots. The nervous symptoms are marked. There will be headache, and in the graver cases delirium and coma. The reflexes at first are greatly exaggerated, but as the cord becomes involved they diminish, and finally disappear. The muscles at first become paretic, and later are entirely paralyzed. The paralysis assumes the form of paraplegia, which will involve more or less of the body as well as the lower limbs, and will ascend as the inflammation ascends, involving the arms if the meningitis extends to the cervical region. There is hyperæsthesia of the skin; the back is rigid, with not infrequently retraction of the head, and even opisthotonos, so that sometimes the differential diagnosis between meningitis and cerebro-spinal meningitis may be difficult. There are apt to be also spasmodic contractions of the muscles. If the meningitis involves the upper cervical region, there may be early death from respiratory paralysis. If the patient survives any length of time, there will be marked wasting, and he will die later from bed-sores, cystitis, and nephritis.

Acute Traumatic Myelitis.

Acute traumatic myelitis, like acute traumatic meningitis, may follow simple—*i. e.* closed—wounds as well as compound—*i. e.* open—injuries, and may even be caused by continuous and severe exercise, especially if the patient is suffering from insufficient food and exposure; as, for instance, in soldiers on the march. Even a single violent muscular effort, as in lifting a heavy weight, may cause it. It is apt to follow concussion of the cord in which there is laceration of its substance with probable hemorrhages. That form which is known as "compression myelitis" attends marked compression of the cord, as by aneurysm of the aorta, producing absorption of the bodies of the vertebræ, cancer of the vertebræ, and fracture and dislocation, in which the bone, if permanently displaced, not only produces a varying amount of primary injury to the cord, but also, from its continuous impinging on the corda, compression myelitis as well.

The vessels are dilated; the pia is red; the cord is swollen and red; the distinction between the white and the gray matter may be lost; and the cord may even become diffluent. The nerve-cells and fibres are swollen and broken down. The myelin escapes from its sheath and forms in drops or globules. The neuroglia melts away, and in old cases corpora amylacea are often found. Secondary degeneration, both ascending and descending, occurs. Suppuration is an uncommon result, except

in case of an infected open wound. If the myelitis extends to the cervical region, it may produce early death by involving the respiratory centre.

The distinction between a chronic myelitis and the acute form is rather to be made by the rapidity of the onset of the attack than by any special difference in the symptoms.

Symptoms.—There may be a chill, and fever which is marked, but in which the temperature does not run very high. Girdle-pain at the level of the lesion may be present, but may soon disappear, or in other cases may be very persistent. Muscular spasms are rare, but if the patient survives, contractures of the limbs are apt to occur. Headache is marked; the functions of the cord are soon lost. There will be temporary hyperæsthesia with moderate pain, not usually much increased by motion. Sensation is early lost to a greater or less extent. The paralysis of motion appears early and rapidly extends upward, and may often become extensive in the course of a few hours or even a few minutes. Acute bed-sores, cystitis, and nephritis are apt to occur, as in injuries to the cord. In consequence of the paralysis of sensation from involvement of the cord, it is necessary to be very careful in the application of external heat; even the application of hot-water bottles in a very short time may produce extensive sloughs. The reflexes are soon lost, but often return in an exaggerated form, unless the myelitis be in the lumbar region, when they are lost permanently. Retention of urine and marked constipation are early symptoms, followed, however, sooner or later by incontinence both of urine and fæces.

Treatment.—The treatment of both acute traumatic meningitis and myelitis must necessarily be unsatisfactory. It must rather be in the direction of the prevention of impending evils than by direct efforts to combat the lesions themselves. The diet must be nourishing, but easily digested. The utmost attention must be paid to the general hygienic care of the patient. The condition of the bladder must be carefully observed, and, if we cannot avoid the catheter, it must be used with the strictest antiseptic precautions. If there be incontinence of urine and fæces, the greatest care must be exercised to keep the patient dry and clean, so that by this means, as well as by frequent change of posture and by attention to the neatness and smoothness of the bed-clothes, bed-sores may possibly be prevented. In hemorrhage ergot has been recommended, and may be useful. Dry and even wet cups, and the continued application of ice to the spine by means of the long rubber ice-bags, are sometimes of service. Mercury and in moderate doses iodide of potassium are perhaps as useful as any remedies, but even in syphilitic cases their effects will often be unsatisfactory.

When the case has become less acute or stationary, tonics, such as iron, quinine, and strychnine in small doses, are indicated. Strychnine should be used very cautiously in cases where the reflexes are exaggerated. Frequent counter-irritation by iodine, mustard, etc., with massage and electricity, will aid in the recovery. Contractures of the limbs should if possible be avoided by extension, by weight and pulley, splints, passive motion, etc. In the use of splints attention must be given especially to avoid points of pressure which might produce sloughing.

Chronic Traumatic Meningo-myelitis.

This is sometimes caused by apparently trifling injuries, such as sprains and contusions, and even very slight accidents result finally sometimes in the most serious secondary degeneration. In railway injuries, as already pointed out, such a chronic meningitis and myelitis may follow and be a real cause of continued disability. The membranes become thickened, and "dense tracts of tissue may pass from the pia into the superficial layers of the white substance" (Gowers), with more or less diffused sclerosis.

Symptoms.—The onset is insidious and indefinite, excepting that acute pains and spasms are usually absent. In consequence of the indefiniteness of the attack at the beginning the slightest symptom should be noted. Very gradually there will be increasing motor paralysis, and to a less degree sensory paralysis. Contractures are apt to be associated with such paralyses. If the lesion be cervical, there is often rapid atrophy of the muscles. Muscular weariness is one of the earliest, most persistent, and marked symptoms. There is apt to be sensation of pins and needles, with more or less extensive dull pain and a girdle sensation around the body. The reflexes gradually become more pronounced, and in addition to the exaggerated knee-jerk there will be very marked ankle-clonus. If the lesion be above the second dorsal vertebra, vision is apt to be interfered with from the loss of control of accommodation.

Treatment.—This is often equally unsatisfactory with that of the acute form. Everything which tends toward mental and physical rest, and especially mental buoyancy, will contribute to the recovery of the patient. Especially if it be a medico-legal case, involving the question of damages, the sooner the case is settled definitely, and for the same reasons as are stated on page 804, the sooner the patient will begin to recover. In other respects the treatment for the more acute form of meningitis and myelitis already noted is applicable to such cases.

Compression of the Spinal Cord.

This may be either acute or chronic.

I. Acute Compression.—This may be due to the sudden giving way of carious vertebræ, to hemorrhage, to the rupture of an aneurysm, to fracture, to dislocation, etc. The membranes may be torn or not, and the cord may be more or less completely crushed. This is followed soon by meningitis and myelitis.

For the **diagnosis, symptoms,** and **treatment** of each of these conditions the reader is referred to the sections of this work upon the various lesions named.

II. Chronic Compression.—This is apt to occur most frequently in Pott's disease, cancer, exostosis, pachymeningitis, tumors, and parasites, and is apt to produce that form of myelitis which is known from its cause as "compression myelitis" (Pl. X. Fig. 4). The pressure may be upon any of the columns of the cord, or the entire thickness of the cord may be involved, producing the phenomena of complete transverse myelitis. The cord may eventually be reduced to a semi-fluid pulp, with ascending and descending secondary degeneration. Sometimes, if very gradual,

instead of softening of the cord it causes gradual atrophy, or even disappearance of the nervous elements, with sclerosis of the small remnant of the cord.

The paralysis varies, sometimes being absent even when the curvature of the spine in Pott's disease is marked, or present when the curvature is very slight, depending more upon the compression than upon the angularity of the spine.

For the **diagnosis, symptoms,** and **treatment** the reader is again referred to the sections upon the several lesions named. In cancer the diagnosis rests upon the history almost uniformly of cancer elsewhere, that of the spine being secondary. The diagnosis of exostosis and parasites is one of extreme difficulty.

Tumors of the Spinal Cord.

Prior to the brilliant paper of Gowers and Horsley,[1] in which they reported the first and most remarkable case on record of the successful diagnosis and removal of a tumor of the spinal cord itself, there had been recorded only four cases of operation on a spinal tumor in the modern strict sense. It is true that Gerster[2] had operated on a sarcoma of several posterior arches in 1878, but his case was not published until 1892; and Bazy[3] had also removed an extra- and intradural hydatid in 1886, but this case also was not made public until 1891.

The four cases published prior to that of Gowers and Horsley were as follows: First, Lecat[4] in 1751 extirpated a cancer of the lumbar spines and laminæ; second, in 1819, Reydellet[5] had extirpated a lumbar hydatid cyst in which there was a very apparent tumor in the lumbar region; third, in 1856, Athol Johnson,[6] and fourth, Holmes in 1885[7] had each operated on fatty tumors which penetrated into the spinal canal by the foramina respectively of the sacrum and the middle dorsal region. None of these cases were in any respect comparable with that of Gowers and Horsley, since they all showed external indications of a tumor. Prior to the publication of their paper spinal tumors were practically beyond surgical reach. Since then there has been opened a wholly new field of surgical effort and achievement, so that since 1887 there have been reported twenty-four other cases which have been removed, after being diagnosticated purely on neurological data, without any external tumor which would indicate their presence. In Gowers and Horsley's paper there are collected 58 cases of spinal tumor, of which 80 per cent. died simply from the direct results of the tumor—namely, exhaustion, pyæmia, and septicæmia, bed-sores, septic pneumonia, and septic nephritis. Of the 58 cases, 57 died, the only case of recovery being the one operated on by Mr. Horsley.

The chief varieties of spinal tumors belong to the connective-tissue group, such as fibroma and sarcoma, the intradural tumors arising especially from the arachnoid, and having not uncommonly a thin capsule or prolongation of the arachnoid which separates them from the cord, with

[1] *Medico-Chir. Trans.*, 1888, lxxi. 377.
[2] *N. Y. Med. Journ.*, 1892, i. 722.
[3] *Congrès français de Chir.*, 1891.
[4] Chipault, *Études de Chir. méd.*, p. 350.
[5] *Ibid.*, *loc. cit.*
[6] *Trans. Path. Soc. London*, 1856, p. 16.
[7] Chipault, *Études de Chir. méd.*, p. 354, Case 5. [I cannot verify the reference in this case.]

which they are rather loosely connected, and therefore may be easily removed (Pl. X. Figs. 2, 3). If not connected with the arachnoid, they are more apt to arise from the dura. The majority not being malignant, they will not, as a rule, return. The sarcomata or the glio-sarcomata which arise in the cord itself are apt to infiltrate the cord, and therefore to be irremovable. Occasionally organized inflammatory products, in consequence of their producing pressure on the cord, are classed as tumors. Thus, Lloyd[1] records a case in which an organized callus at the seat of an ununited fracture of the right lamina of the third lumbar vertebræ compressed the cauda equina and was removed. The operation was followed by a gratifying recovery. Macewen[2] records a case of connective-tissue tumor at the seat of an angular curvature of the spine an eighth of an inch in thickness, the removal of which enabled the boy five years later to join even in athletic games. Even the removal of slight connective-tissue adhesions between the dura and the cord has been followed by great improvement, as in the case of Dercum and White.[3]

In addition to such tumors arising in the cord or springing from its membranes, other tumors may arise from the bones, especially the carcinomata, or enter the spinal canal through the intervertebral foramina. Thus, Caselli[4] removed a small osteoma compressing the dura, followed by entire cure. The carcinomata are rarely primary, but usually secondary deposits following carcinoma of the breast or other parts of the body. Occasionally also aneurysms by destruction of the bodies of the vertebræ will press upon the cord and produce the nervous phenomena of tumors, but they are usually accompanied by other physical phenomena, by which, except possibly in the earlier stages, we are enabled to diagnosticate their presence. Gummata and tubercular tumors of the cord are also found, and occasionally parasitic cysts, especially the echinococcus. Wyeth[5] reports the removal of a tuberculoma with entire cure.

Spinal tumors are generally small on account of the limited space in which they develop, death following before they can grow to any size. They may extend, however, in a vertical direction to a moderate length. They occur in any situation in the cord, but are commonly seen just below the centre of the cervical region and at the upper and lower ends of the dorsal region. The symptoms of course will vary in accordance with the location of the tumor. They occur rather more frequently in women than in men, for some unknown reason, unless it be the traumatisms of parturition.

The age at which they occur has been carefully analyzed by Gowers and Horsley, and they have shown that the average age in extradural tumors for lipomata, which are apt to be congenital, is two and a half years; for sarcoma, eighteen years; for echinococcus cysts, thirty-four years; and for tubercle, thirty-nine years. In the intradural tumors myxoma has for its extreme limits nineteen and sixty years, with an average age of forty-three; fibroma, of forty-four; sarcoma, forty-one; psammoma, fifty-one; and tubercle, eighteen and a half years. If an intradural growth is present in a person beyond thirty years of age, it is almost certainly not tubercular.

[1] *Amer. Journ. Med. Sci.*, July, 1891, 29.
[2] *Lancet*, 1885, i. 881.
[3] *Annals Surg.*, 1889, ix. 424.
[4] *Rif. Med.*, 1893, iv. 380.
[5] *Annals Surg.*, 1894, ii. 153.

The **causes** for tumor are, as a rule, uncertain. Lipomata are usually congenital, although they may not show their effects until later. In nearly half the cases cold and injury are the assigned causes. The duration of the disease also will enable us to some extent to decide whether a suspected tumor is intra- or extradural, the average duration of life in intradural tumors, which are slow-growing and may cover several years, being about two and a half years, whereas the average for extradural tumors is about one year.

The importance even of small tumors of the cord is derived chiefly from their effects upon the cord itself. The canal in which they must grow being very small in calibre, extradural growths very easily produce symptoms of compression myelitis, with atrophy and inflammatory changes, and more or less extensive Wallerian degeneration. If they arise within the cord, they also produce atrophy, myelitis, and secondary degeneration.

Symptoms.—In both extra- and intradural tumors the three principal symptoms are—first, pain; secondly, motor paralysis; and third, sensory paralysis. Each of these will require some consideration.

First: Pain.—This is usually the earliest of all the symptoms. It is apt to be obscure, and is not infrequently mistaken for rheumatism. But the march of the symptoms is very different from that seen in rheumatism. No such muscular or sensory paralysis follows the latter disease, and gradually, as the case develops its graver symptoms, no doubt will exist as to the nature of the trouble. The pain is rarely sudden, but increases gradually. If there be a sudden onset or increase, it is apt to be due either to hemorrhage or rupture of a cyst. The pain is apt to radiate in the course of the nerves, especially those of one side if the tumor be unilateral, and is increased on movement. It is often described as burning, boring, and shooting in character. In extradural tumors it is apt to be incompletely unilateral in character, and in about 29 per cent. there is transference to the opposite side. In intradural tumors the transference has been observed in 48 per cent., producing Brown-Séquard's paralysis; that is to say, in consequence of the sensory and motor fibres in the cord crossing at different levels, there will be anæsthesia on the opposite side to that on which the tumor exists, with hyperæsthesia, ataxia, motor paralysis, and exaggerated reflexes on the same side. Careful observation of this difference of the symptoms of the two sides of the body may enable us to locate the tumor much more exactly than otherwise. Muscular spasms are apt to attend the pain. In extradural growths 35 per cent. of the cases suffer from such spasms, whereas in intradural growths 61 per cent. so suffer.

The pain *is never referred to a higher level than the lesion, but always below, and sometimes considerably below.* Thus in the case on which Horsley operated, from the pain and anæsthesia, the tumor was diagnosticated to be in connection with the roots of the fifth dorsal nerve, but the tumor was found four inches above the line of anæsthesia and involved the roots of the third nerve. It is therefore of the greatest importance, as Horsley has pointed out, in any operation for tumor to open the spine to the very uttermost upper limit indicated by even slight changes of sensation, lest we should miss the small growth entirely, as very nearly occurred in his case. In this case there was anæsthesia as

high as the area of skin supplied by the fifth dorsal nerve, with doubtful diminution of sensibility in the area supplied by the fourth. In the region supplied by the fifth and seventh intercostal nerves there was severe pain, much more marked on the left side than on the right, and increased to agony on any movement. When the laminæ of the third, fourth, fifth, sixth, and seventh dorsal vertebræ had been removed, nothing abnormal was discovered, and it was almost decided to abandon further interference. It was only after removing the lamina of the second dorsal that the tumor was discovered. Bruns[1] operated for a spinal tumor and failed to discover it, since it lay at a higher level than he thought.

If the pain is fixed, and is also accompanied by weakness which is felt by the patient at the same point as the pain, and if this weakness is increased by fatigue, it is a most important localizing symptom. Tenderness at the seat of the tumor almost always exists, and in the dorsal region tenderness to percussion is apt to exist at a lower level than that of the tumor. This does not seem to be true of the cervical region. Often there is numbness with a sensation of pins and needles, and hyperæsthesia or paræsthesia and a girdle sensation at or near the level of the tumor.

Secondly: the Motor Symptoms.—The back is apt to be very rigid, especially if the tumor is in the cervical region, in consequence both of the pain and probably of the irritation of the nerves going to the muscles. This rigidity exists in 50 per cent. of intradural tumors and 15 per cent. of extradural tumors. It occasions, especially if unilateral, some curvature of the spine, the concavity being on the same side as the tumor. The same irritation produces spasm, accompanied sometimes by extension, but later by flexion of the extremities as the paralysis from pressure increases. Loss of motion usually precedes loss of sensation, but this may vary somewhat in accordance with the situation of the tumor in reference to the columns of the cord. The motor paralysis is usually gradual in its onset, but through an acute myelitis or hemorrhage it may come on suddenly, though this is rare. In this case it may improve if it be purely from pressure, but if from myelitis, hemorrhage, or infiltration of the tumor, the motor paralysis is almost certain to be permanent.

The march of the paralysis is usually from above downward, in marked distinction to the sensory paralysis, which begins in the soles of the feet and ascends instead of descends. The muscular reflexes at first are exaggerated, but then diminish, the loss again beginning with the plantar reflex and passing upward. Sometimes at the level of the tumor the reflexes will be abolished early, while below that they are increased, together with other phenomena of spastic paralysis. For instance, if the tumor is in the cervical region, the reflexes of the arm may be abolished, while those of the trunk and legs are exaggerated. In the dorsal region the reflexes of the thorax or abdomen may be gone, while those of the legs are exaggerated. It must not, however, be forgotten as to these and other symptoms of a localizing character that occasionally tumors of the spinal cord are multiple, and will combine, therefore, the localizing symptoms of different regions. In certain regions of the cord also peculiar symptoms will arise. Thus, if the tumor be as high as the

[1] *Neurolog. Centralbl.*, 1894, 201.

second dorsal vertebra or above that point, it will involve the cilio-spinal centre, and the pupil on the same side will be smaller from paralysis of the sympathetic. In the cervical region respiratory phenomena, especially cough or dyspnœa, are apt to occur, together with atrophy of the upper arm if the tumor be in the upper part of the cervical enlargement, and of the muscles of the forearm and hand if it be in the lower part of the same enlargement. If it be in the dorsal region, the limits of the sensory paralysis or paræsthesia are much more evenly defined than if it be in the cervical, as the dorsal nerves do not form any plexuses. Careful observation is still necessary as to atrophy of the muscles of the trunk, and in fact of the entire body, especially the gradual successive involvement of different muscles. If the tumor be in the upper lumbar region, the muscles of the hip and thigh will become atrophied; if in the lower lumbar region, the muscles of the leg.

Along with the paralysis comes always, as has already been described in Fracture and Dislocation, retention and incontinence of urine, with cystitis, etc., paralysis of the rectum as well as of the bladder, and severe bed-sores, with their usual distressing and generally fatal results, which have already been described (p. 809).

Prognosis.—There is but one prognosis—namely, death, usually after one or several years of fluctuating conditions, but on the whole with a downward tendency. The only exceptions to this are cases of gummata of the cord, which may be relieved, or even cured, by a suitable antisyphilitic treatment. The whole subject of syphilis of the cord is treated elsewhere.

Diagnosis.—It is often extremely difficult, especially in the early stages of a spinal tumor, to diagnosticate its presence. Of course, if there are diathetic conditions present, such as constitutional syphilis or cancer of the breast, the character of the tumor, either a gumma or secondary cancer, may be suspected. Apart from this, the diagnosis must be based first on the severe pain, not seldom accompanied with muscular spasm; secondly, the local tenderness and rigidity of the spine, the pain and tenderness both being increased by movement; thirdly, on paralysis of motion; and fourthly, of sensation.

Apart from tumors arising in connection with diathetic conditions, the character of the tumor is difficult to diagnosticate, excepting that connective-tissue tumors are more common than others. The site of the tumor must be diagnosticated by the symptoms already given in various regions of the cord, reference being made to the table on p. 815.

Treatment.—A reference to Horsley's paper shows (on p. 427) that 80 per cent. of the 58 cases which he has tabulated "could have been relieved entirely by operation, and those which were hopeless might by relief of pressure have been granted an euthanasia."

The first steps of the operation are described later under the head of Technique (p. 858). Once that the tumor has been laid bare, the further steps must be determined by its character, extent, relations, etc. If it be a tumor infiltrating the spinal cord, of course nothing can be done. If it be a tumor of the membranes, or, as in Gowers and Horsley's case, loosely connected with the cord, it may be removed. In several cases in which there has been a thickening of the connective tissue or granulation tissue outside the cord this has been removed with advantage.

Chipault[1] has collected 22 cases of operation on spinal tumors, to which I have added 3, of which 11 recovered, 11 died, and the result in 3 is uncertain.

Starr[2] has collected 100 cases of tumors of the spinal cord with fairly satisfactory histories. In 54 it should have been possible to make a diagnosis and reach a conclusion as to the feasibility of an operation. From the pathological point of view, in 75 the tumor could probably have been removed—a much larger percentage than in brain-tumors. Though the results at present have been rather discouraging, yet such a review is an incentive to more frequent operations. For a new operation such a large percentage of recoveries is most hopeful. A few of the cases may be summarized with advantage. The case operated on by Horsley has already been referred to.

Wright[3] operated on a case of fibro-sarcoma of the neck involving the brachial plexus, which invaded the cord through the intervertebral foramen of the third cervical nerve. The tumor was easily removed, and its prolongation into the intervertebral foramen was curetted. The hemorrhage was insignificant. The patient was well in three weeks. The day after the operation the contractures had lessened and soon ceased, and the patient recovered almost entirely.

Laquer and Rehn[4] have reported a case of lymphangioma cavernosum which compressed the cauda equina. The patient, aged nineteen, first noticed pain in the sacral region and in the posterior portion of the thigh in September, 1888. In two years paralysis of the bladder and rectum followed, with loss of knee-jerk on the right side and weakening of it on the left. There was no ataxia, anæsthesia, or atrophy, but the patient walked with a stiff leg and stooped slightly. He became exhausted after taking a few steps, and opiates were necessary to procure sleep. There was, however, no decided muscular paralysis. The operation was done October 14, 1890, the sacral spinal canal being exposed by chiselling upward. At the upper border of the second sacral vertebra an extradural tumor as thick as the finger, with a blue translucent capsule, was found. It had no connection with either the nerve-roots or the dura mater, but compressed them. The tumor was removed with scissors, forceps, and sharp spoon. The patient recovered and was discharged in a month. His pain had entirely disappeared, the patellar reflexes were restored, and he was able to walk, and even to work, without fatigue, for a half day.

Roy[5] reported the case of a man who suffered from a sudden sense of constriction in the inferior portion of the abdomen, and was suddenly paralyzed, with anæsthesia extending to within two inches of the umbilicus. The bladder and bowels were also completely paralyzed. The last four dorsal arches were removed and the dura opened, when the tumor was discovered lying on the medulla. Very slight hemorrhage followed its removal. The girdle sensation was relieved at once, sensation was re-established, and the paralysis of the bladder and bowels disappeared. The patient was able to walk with a cane.

[1] *Étude de Chir. médul.*, p. 350.
[2] *Med. News*, Feb. 23, 1895, 222.
[3] Thorburn, *Surgery of the Spinal Cord*, p. 168.
[4] *Archiv f. klin. Chir.*, xlii. 812.
[5] *N. Y. Med. Record*, 1890, ii. 564.

Syringomyelia.

So far as I know, Abbe's is the only case of this form of glioma of the spinal cord that has been operated on and reported.[1] He removed the ninth, tenth, and eleventh dorsal laminæ, and found a fusiform dilatation of the spinal cord, with no pulsation. On slitting up the dura no cerebro-spinal fluid escaped. By touch a lemon-shaped central cyst was discovered, and aspirated by a hypodermatic syringe. The withdrawal of ℥jss of fluid was followed by collapse of the cyst. The patient recovered from the operation and showed some improvement, but died seven months later from cystitis and other complications. I have myself done two operations on similar cases which have not as yet been reported. In one of them, done Jan. 31, 1891, at the Philadelphia Orthopædic Hospital and Infirmary for Nervous Diseases, I exposed the lower cervical and upper dorsal cord, and found what I and the experienced neurologists present all supposed to be a very thin, grayish-white layer of lymph on the surface of the cord, under which was a dark blackish-gray tumor, which I thought lay posterior to the cord. In a few minutes my suspicions were aroused that I was wrong, and I discovered that the excessively thin layer of supposed lymph was the thinned layer of the white matter of the cord, and that the mass which I took for a tumor back of the cord was really a glioma of the cord itself. I, of course, instantly desisted from operation and closed the wound. The patient lived five days, and the post-mortem revealed a very extensive syringomyelia.

The second case I have every reason to believe was a syringomyelia from appearances, but, happily, I have not yet had the opportunity of making a post-mortem. The operation was done on a patient of Drs. Putnam, Walton, and Warren of Boston on December 28, 1891. In that case I removed the arches of the tenth, eleventh, and twelfth dorsal vertebræ. The cord was greatly thickened, of a dark-gray color, and was adherent to the dura. No cerebro-spinal fluid escaped on slitting up the membranes, which I did not suture, but left open for about two inches in order to relieve the pressure on the cord. No trouble has arisen from any adhesion between the cord and the adjacent soft parts. The patient has shown a little improvement. There was evidently no localized cyst, but probably an extensive syringomyelia.

These, so far as I know, are the only three cases that have been operated on. These results show that where the diagnosis of syringomyelia can be made beforehand—a difficult task in many cases—it would be best to abstain from operation.

Actinomycosis of the Spine.

This is a rare disease. In the *Münchener med. Woch.*, June 14, 1892, Heuck has reported the case of a girl of sixteen who nine months before her admission became anæmic, and had influenza a month afterward. This was followed by cough and general poor health. Four months later she had a severe fall, which was followed by pain in the left side and back, with signs of pleural effusion on both sides. No tubercle

[1] *Journal of Nerv. and Ment. Dis.*, July, 1892, 512.

bacilli were found in the sputum. A fluctuating swelling appeared on the left side of the spine, with much local tenderness, increase of the knee-jerk, and ankle-clonus on the right side. A second distinct isolated swelling appeared in the left scapular line, exploration of which furnished a blood-stained fluid, with small granules found to be actinomyces. The same fungus appeared in the sputum. The patient died eighteen months after the beginning of her illness. An abscess-cavity was found from the fourth to the eighth ribs which had extended to the interior of the thorax and involved the lung. The last two dorsal and first two lumbar vertebræ were partly destroyed by the invasion of the fungus, which was found in the teeth, but in no other portions of the body.

Acute Osteomyelitis of the Vertebræ.

Common as is this acute disorder in the long bones, it is rarely seen in the vertebræ. This is in sharp contrast to the chronic tubercular form (Pott's disease), which is so frequent in these bones. Tournadour[1] refers in his thesis to 13 cases, to several of which I have not had access in the original. It is evident that while some of them were cases of true osteomyelitis of the vertebræ, several others were not cases of osteomyelitis, but of arthritis of the spine with pyæmia, subperiosteal abscess with pyæmia, Pott's disease, etc. Lannelongue[2] in 1879 published apparently the first observation in which the disease was clearly recognized. His case was a boy of twelve, who after a fall suffered with pain and fever. An abscess developed in the sacro-lumbar region, and when it was opened denuded bone was felt. Secondary osteomyelitis developed also in the tibia and fibula of one leg and in one radius. He died from pyæmic arthritis and pneumonia. The osteomyelitis, presumably traumatic in origin, started in the third lumbar veterbra, and metastatic abscesses were found in the lungs and kidneys, with marked valvular endocarditis. So far as I know, only nine other cases are on record. Witzel[3] refers to 5 cases by Stanley, König, Valleix, Huron, and himself. In addition to these, I have found 4 other cases by Deaver and Lloyd,[4] Chipault,[5] and 2 cases by Morian.[6]

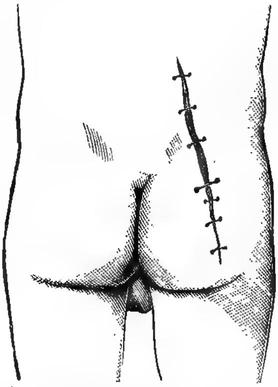
In Deaver and Lloyd's case there was paresis of the left arm, paralysis of the left leg, with exaggerated reflexes, but no disturbance of sensibility. The laminæ of the third and fourth cervical vertebræ were removed, exposing a small bony tumor, but the soft parts seemed to be normal. The laminæ were softened and enlarged from osteomyelitis, and some pus was found in the cancellated tissue. The dura mater was intact at the bottom of the wound, the connective tissue, including the blood-vessels, having disappeared. The membranes were not opened. An exploring needle was thrust into the cord with negative results. The patient's breathing became labored, and she died on the third day. Death was attributed to inhibition of the phrenic nerve, possibly as a result of the injury by the exploring needle.

The case reported by Chipault is that of a child of four who was

[1] "Osteomyelite de la Colonne vertébrale," *Thèse de Paris*, 1890.
[2] *De l'Osteomyelite aiguë pendant la Croissance.*
[3] *Gerhardt's Handb. d. Kinderkrankh.*, 1887, Bd. vi. Abth. 1, 427 *et seq.*
[4] *Amer. Journ. Med. Sci.*, December, 1888, 564.
[5] *Études de Chir. méd.*, 367.
[6] *Deutsch. med. Woch.*, 1893, xix. 1258.

apparently dying with a temperature of 104° F. and beginning infectious endocarditis. Deep fluctuation was felt in the right buttock, with œdema up to the twelfth right rib. An incision was made from the twelfth rib nearly to the gluteo-femoral crease (Fig. 487). An immense quantity of pus was discharged, and by the finger the anterior surfaces of the sacrum and the lumbar vertebræ were found to be denuded of periosteum. The cavity was freely curetted, disinfected, and drained, and the child was well in two months. Valleix's case is almost an exact counterpart of this.

FIG. 487.



Cicatrix after operation for osteomyelitis of the lumbar vertebræ (Chipault).

Morian's first case was that of a boy of ten, with pain in his loins, headache, fever, and rigid back. After ten days or more a swelling appeared on each side of the lumbar spine. At the operation the fourth lumbar spine and arches were removed, giving exit to pus; later, septic abscesses in the foot and arm were opened. The patient recovered. His second case was a boy of seventeen, with a similar swelling over the eleventh and twelfth dorsal vertebræ, two fingers' breadth from the middle line. On the seventeenth day the swelling was incised and packed with iodoform gauze. The bodies of the vertebræ were found to be bare. At first the boy improved, but death followed on the fifth day from involvement of the pleura. In each of these last three cases a staphylococcus infection was found.

The disease runs a less favorable course than in the long bones, both by reason of its inaccessible position and of the spongy character of the bones. It is more common in the bodies, six out of nine cases showing involvement of the bodies and three of the arches. The onset is sudden, with fever, localized pain, and rigid back, so that if it occurs in the cervical region it may resemble a case of cerebro-spinal meningitis, the head being drawn back and the pupils unequal. The disease can be located later by the swelling, as well as the pain, though both may come on before any diagnosis can be made. It may involve the membranes of the cord on the one hand, or the pleura or the peritoneum on the other.

The differential **diagnosis** from acute rheumatism, acute pneumonia, and lumbago may be difficult. Acute rheumatism, however, rarely attacks the spine, and will be accompanied usually with evidences of rheumatism elsewhere. Acute pneumonia would show an altered physical condition of the lungs as well as of the back. Lumbago also does not usually present such severe symptoms.

The **prognosis** is both in proportion to the gravity of the symptoms and to the situation of the disease. If in the dorsal region, where the pleura is easily involved, it is the most unfavorable.

The **treatment** is by operation as early as a definite diagnosis of the nature and locality of the disease can be made. The arches, if they are involved, should be removed. If the disease has attacked the bodies of the vertebræ, they may sometimes be reached from the focus of pus, and,

if possible, should be curetted, disinfected, and either drained or packed with iodoform gauze.

Similar secondary development of acute infectious osteomyelitis may follow the exanthemata. The **symptoms, diagnosis,** and **treatment** are the same as above described.

PRIMARY TUBERCULOSIS OF THE ARCHES.

Tuberculosis of the bodies of the vertebræ (or Pott's disease) is extremely common of course, and is considered elsewhere, but tuberculosis of the arches is very rare. I have made no extensive search for recorded cases, but have only a memorandum of the following case. Roberts[1] has reported the case of a girl of ten who had fallen the height of two steps three months before he saw her. Paraplegia with subsequent bed-sores soon followed. There was no marked deformity of the spine, though later swelling appeared in the mid-dorsal region, but evidently not the ordinary kyphosis. An incision revealed caseous matter and tubercular bone. Two vertebral arches were removed, and were so softened that they did not require the rongeur forceps, but were cut with a knife. Very active venous bleeding occurred, though apparently not to an alarming extent, but she died on the table from shock and hemorrhage. The post-mortem showed that the laminæ alone were involved. The bacillus tuberculosis was obtained by culture.

The **treatment** adopted by Roberts in this case was evidently the only proper one, in spite of the fact that the result was so unfortunate.

SPINAL DRAINAGE FOR TUBERCULAR MENINGITIS AND HYDROCEPHALUS.

These diseases are almost always absolutely fatal. In the *Lancet* for 1891, i. 931, Wynter proposed to drain away the cerebro-spinal fluid, not by tapping the ventricles, but by indirect drainage through puncture of the membranes of the cord in the lumbar region. He reported four cases, all of them, unfortunately, fatal. The first case was a boy of three years of age, who was comatose and had marked Cheyne-Stokes respiration. The child was held in the sitting posture, no anæsthetic being needed. A small incision was made in the skin and a trocar inserted until the lamina of the second lumbar vertebra was reached. The point was then directed downward and pushed through the theca of the cord, when the cerebro-spinal fluid at once welled up. A piece of rubber tubing was then attached to the tube. Considerable improvement followed in the breathing, in his color, and he was once more able to swallow. Cessation of the escape of the fluid was followed by death. No evidence of a puncture by the trocar could be found.

In the second case Mr. Hulke removed the spine and right lamina of the second lumbar vertebra, punctured the theca with a knife, and inserted a drainage-tube. The temperature fell from 102° F. to the normal, but on the third day, when the aperture closed and the fluid ceased to escape, coma and strabismus set in, and the child died the next day.

In the third case Mr. A. P. Gould drained the subdural space in a similar manner, and stitched the margins of the theca to the edges of the

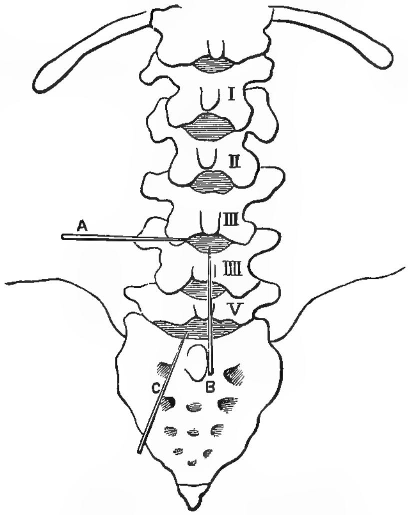
[1] *Philada. Polyclinic,* Feb., 1894.

wound to prevent its closing. Immediate improvement followed, but four hours afterward death supervened.

In the fourth case also the child died in three hours.

Quincke[1] reports ten similar operations for hydrocephalus, pressure being made upon the skull at the same time. One case was cured; in two the results were probably due to the other measures employed; in three there was temporary improvement; none of them died. He calls attention to the fact that the cord in infants extends to the third lumbar vertebra, hence the puncture should be made in the third or fourth intervertebral space. In infants the cauda equina is in two lateral bundles, separated by a space about five millimetres broad. The third and fourth lumbar spaces measure eighteen to twenty millimetres transversely and ten to fifteen vertically; the depth of puncture to reach the cord in infants is about two centimetres, in adults about four to six centimetres.

Fig. 488.



Method of puncture for spinal drainage. *a*, Quincke's method; *b*, Marfan's; *c*, Chipault's (Chipault).

Marfan, instead of puncturing as Quincke does, forward and toward the median line, directs the point of the trocar upward and forward (Fig. 488), following the upper border of the spinous process. Chipault advises the puncture to be made in the lumbo-sacral space between the fifth lumbar vertebra and the first sacral, as this space is very large, and the danger to the nerves is lessened, and the trocar reaches the inferior arachnoid cul-de-sac.

Parkin[2] proposed as a substitute for this spinal drainage to puncture the subarachnoid space to relieve the intercranial pressure in hydrocephalus and tubercular meningitis. He trephines the occipital bone, and reaches the subarachnoid space under the cerebellum (Fig. 489). He reports four cases with two recoveries, and Ord and Waterhouse[3] have added another case of almost certain tubercular meningitis cured by an identical operation. The method is certainly deserving of a more extended trial.

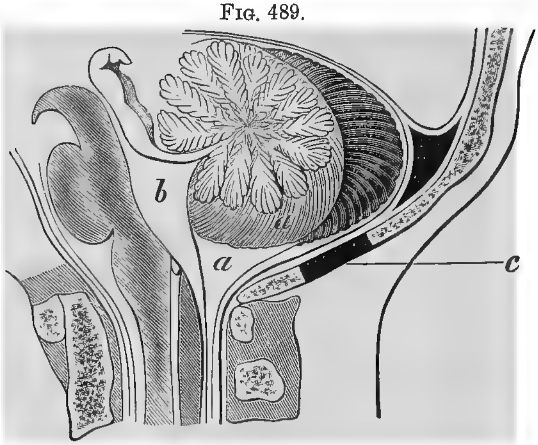
Stephen Paget[4] has recorded a case of acute meningitis in which he removed the posterior arches of the fourth and fifth cervical vertebræ, incised the dura, and drained away the cerebro-spinal fluid, but with a fatal result the next day. The autopsy showed that the cerebral drainage was insufficient. Parkin's operation would probably have been the better.

Browning[5] has practised spinal drainage in a few cases, without encouraging results, and he thinks its chief value will probably be as a

[1] *Berliner klin. Woch.*, 1891, Nos. 38 and 39.
[2] Parkin, *Lancet*, 1893, ii. 23 and 1244.
[3] *Lancet*, 1894, i. 597.
[4] *Lancet*, 1893, ii. 873.
[5] *Journ. Nerv. and Ment. Dis.*, Oct., 1894, 659.

palliative in internal hydrocephalus. He points out the danger of elevating the head during the operation. Dana[1] states that he has employed

Fig. 489.



Vertical section of base of skull immediately to the right of the median line: *a*, basal sub-arachnoid cavity and its relation to the cerebellum; *b*, fourth ventricle; *c*, site of trephine aperture (Parkin).

the method three times in the "wet brain" of alcoholics, with two recoveries.

Ziemssen[2] and others in the debate on his paper have made an important additional contribution to the subject. Ziemssen has used Quincke's method in cerebro-spinal meningitis, tubercular meningitis, hydrocephalus, brain-tumors, and spinal affections, even repeating it five times in the same patient within fifteen days. Improvement followed, but the final result was unknown. He advises puncture between the third and fourth or fourth and fifth lumbar vertebræ, the back of the child being strongly flexed to widen the spaces. He advises the use of an anæsthetic. The fluid may be clear or turbid. As much as ninety-one cubic centimetres of fluid have been withdrawn. No positive satisfactory bacteriological cultures were obtained.

As to the immediate result, he observed a decided lessening of the headache, and that a repetition of the puncture produced increased benefit, but the final fatal result was not averted. As a palliative it would seem, therefore, to be of value, especially in the lessening of the headache from lessened intracranial pressure. He observes that the method may hereafter be of value in diagnosis, and possibly also in treatment, by the introduction through the cannula of direct medicaments to the spinal cord and membranes for local therapeusis. He injected methyl-violet post-mortem in a case of hydrocephalus, and found that it had reached the cervical region.

In the debate Bruns proposed to combine puncture with trephining in order to further lessen the intracranial pressure if the trephining alone did not relieve it.

Quincke stated that he had done the operation forty-one times. He

[1] *Journ. Nerv. and Ment. Dis.*, Oct., 1894, p. 682.
[2] *Verhandl. des 12ten Kongress f. inner. Med.*, 1893, 197.

drew attention to its possible diagnostic value, especially as to the nature of the fluid, the microscopical elements present, the percentage of albumin, and the degree of the pressure. The normal specific gravity of the cerebro-spinal fluid is 1007 to 1009, and the albumin is present from 0.5 to 1.0 part per 1000. When the proportion of the latter rises to 1 or 2 parts per 1000 there is an acute increase in the inflammation and the exudation. If the fluid is bloody, the inflammation is of a higher grade. He has seen the albumin rise to 3, 5, and even 7 parts per 1000. The normal pressure is under 150 millimetres. In some cases it may rise to 500, or even 700, m.m. Quincke, and also Sahli, have endeavored to establish continuous drainage by incision and tubing, but without success.

Intraspinal Division of the Posterior Nerve-roots for Inveterate Neuralgia.

Seven cases in which this operation has been done have been recorded. The first was done by Abbe in a man of forty-four.[1] For fourteen months before the operation he had suffered from neuralgia of the brachial plexus. The nerves of the arm were first stretched, and later the arm was amputated at the shoulder-joint. Dana then proposed that the spinal cord should be exposed with a view either to the removal of the tumor or to remedy any inflammatory process if either of these lesions should be found, and if neither of them existed that then the posterior roots of the nerves should be divided within the spinal canal. December 31, 1888, Abbe put in practice this suggestion. Half of the posterior arch of the fourth and all of the arches of the fifth, sixth, and seventh cervical vertebræ were removed. The dura was exposed for two inches, but no tumor was found. The intervertebral foramina were then explored by a curved hook, and the sixth and seventh cervical nerves were stretched so that a short loop of each was raised. The operation was done between the dura and the bone, as the dura had not been opened. The fifth nerve could not be raised by the hook without exciting considerable hemorrhage. The sixth and seventh nerves were then cut across just outside the dura, both motor and sensory roots thus being divided. The wound was packed with iodoform gauze, but not closed. The neuralgia soon returned, and accordingly two days later, without ether, the wound was exposed and the dura opened. It is noticeable that "the dura was scarcely at all sensitive to cutting," in contradiction to Mr. Horsley's statement that in spinal operations profound anæsthesia is required when the dura is divided, on account of its extreme sensibility. The posterior roots of the seventh and eighth cervical nerves were now divided within the dura, the dura being then sutured with catgut and the entire wound closed. The character of his pain changed some, and in January, 1893, Dr. Abbe wrote me that the patient "still had considerable neuralgia, if his statements can be taken for truth."

In the *N. Y. Med. Record*, July 26, 1890, Abbe reports a second case, which I had the pleasure of witnessing myself. The dura was opened, and a portion of the posterior roots of the sixth, seventh, and eighth cervical and first dorsal nerves was exsected. As in the former case, the relief was only temporary. The parts supplied by the divided nerves

[1] *N. Y. Med. Rec.*, Feb. 9, 1889.

were persistently anæsthetic, but the pain returned just as in so many cases of neurectomy for tic douloureux, and the condition of the second patient was practically the same as that of the first.

The third case is reported by Bennett,[1] a man with constitutional syphilis, who had suffered agonizing pain in the left leg, and later in the latissimus dorsi and erector spinæ muscles, with violent spasms. After an incision over the tibia which gave no relief the leg was amputated at the knee. The sciatic nerve was then stretched, and finally excised without any benefit. By an incision six inches long, with its centre at the eleventh dorsal spine, the lower four lumbar nerves were divided. This division caused arrest of the pulse, which, however, returned upon gentle pressure upon the cord with a warm sponge. Then the first two sacral nerves were divided, this also being followed by a similar effect upon the heart. Bennett discovered later that he had not divided the second lumbar, as he had thought at the time of operation. On the fifth day the patient was comfortable and without any pain, though the spasms had returned. By the tenth day the wound was healed. Unfortunately, on the eleventh day he suddenly died from cerebral apoplexy. The post-mortem showed sclerosis of the posterior root-zone and the columns of Goll.

Two other cases were reported by Horsley at the International Congress of 1890 in Berlin.[2] In one of them (the fourth case) the posterior roots of the eighth and ninth dorsal nerves on the right side were resected with temporary relief, but the neuralgia returned in other nerves. In the other (the fifth case) the posterior roots of the seventh and eighth cervical were resected, with "much relief."

Fig. 490.

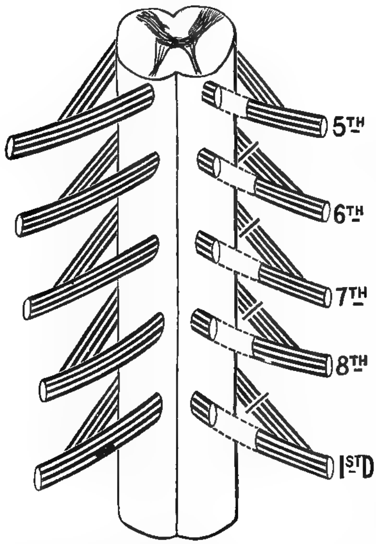


Diagram of intradural resection of posterior roots of brachial plexus, with section of the anterior roots (Abbe).

Abbe has recently reported a sixth case,[3] a man forty years of age, who had had spastic paralysis of the right arm and leg since childhood, with athetoid motion of the upper limb and great pain, so that the arm had been amputated at the shoulder-joint five years before the resection of the spinal nerve-roots, which was done June 4, 1894. A quarter of an inch of the fifth, sixth, seventh, and eighth cervical and first dorsal nerves was resected (Fig. 490), and in addition to that, as the arm was gone and section of the anterior nerve-roots would not involve loss of function, and might prevent the athetoid movements, the anterior roots were cut, excepting that of the fifth, which was left intact on account of its relation to the phrenic nerve. "The pain abated very much, and the spasms almost entirely disappeared after the operation."

[1] *Med.-Chir. Trans.*, 1889, lxxii. p. 329. [2] *Brit. Med. Journ.*, 1890, ii. 1289.
[3] *Annals of Surgery*, Jan., 1895, p. 53.

He also reports at the same time on the condition of his two former similar operations after an interval of five and six years respectively: "In both there had been very great, but not complete, relief from pain up to the present time."

McCosh reported a seventh case at the same time with Abbe, in which he had cut two of the posterior dorsal roots, though no anæsthesia followed, owing to the free anastomosis and overlapping of the branches of these nerves.

One advantage of the operation was pointed out in the very first case by Dana: that is, if a tumor or other lesion exist, it can be dealt with during the operation, instead of division of the posterior nerve-roots.

The result obtained in these cases is similar, of course, to that which we obtained by neurectomy for tic douloureux. In both operations, if the disease involves the peripheral nerves alone, the result is somewhat unexpected, inasmuch as in sensory nerves the Wallerian degeneration proceeds centrally, and should have destroyed, therefore, the spinal ends of the nerve-fibres. The pain of neurasthenics, or the "pain-habit," as it has been called, seems to be so established by the long duration of these cases that an earlier operation would appear to promise better results. Abbe's own opinion is "that the operation is a safe one, and if the hysterical element can be eliminated from any proper case, it should be tried still further, inasmuch as it cannot disable the arm in the slightest degree," the motor roots being left intact—an opinion in which I fully agree. I have recently stretched first the brachial plexus, then the ulnar nerve, then resected the ulnar nerve, and finally amputated at the shoulder-joint in a precisely similar case, in which I urged the patient—ineffectually, however—to allow me to perform the intra-spinal division of the posterior roots in the early stage of the disease.

The technique of the operation is that of an ordinary laminectomy (p. 858) up to the disclosure of the dura. This is then opened, the nerves identified, and the posterior nerve-roots alone divided. If, as in Abbe's last case, the limb has been amputated, but the spasms persist in the stump, the anterior nerve-roots should also be divided. In order to identify the nerves one has to deal with, it is advisable to nick the skin opposite the spine of any selected vertebra; for instance, the seventh cervical. When the cord and nerves are then exposed, one can count up or down and readily fix upon the nerves which he is seeking. The closure of the wound and the after-treatment are the same as after laminectomy.

The resemblance of this operation to that of neurectomy of the fifth nerve in trigeminal neuralgia has already been spoken of. The operation is one of not a little mechanical difficulty and nicety, but not of excessive danger, no one of the six cases having succumbed to the operation. The recent successful operations upon the Gasserian ganglion would lead me to suggest that the ganglia on the posterior roots should be broken up, as well as the posterior nerve-roots resected. It may be argued, of course, that resection of the nerve-roots cuts off all connection between the nerve and the ganglion on the one side and the cord on the other, but we know the extraordinary powers of recuperation and re-establishment of peripheral nerves, as in the fifth, and hence the very small

portion of the root which can be exsected within the dura may possibly allow the gap to be closed and the continuity of the nerve thus to be reestablished. I have seen in several instances the inferior dental nerve reproduced in the entire length of the inferior dental canal. Hence destruction of the ganglion, as well as resection of the nerve-root, may possibly make the results of the operation more certain. Of course care should be taken not to injure the motor root while breaking up the ganglion. As in trigeminal neuralgia, the peripheral operations are less dangerous than the central one, and for a time are efficacious. Hence it is probable that peripheral operations by stretching or resection of the nerves, or even amputation, might be justified before the posterior nerve-roots are divided, but my own opinion is in favor of a primary resection of the nerve-roots in view of the failure of repeated and serious operations, such as even amputation at the shoulder-joint or in the thigh. When, therefore, we have to deal with such neuralgias, intraspinal resection should, in my opinion, be rather the first than the last operation.

Technique of Laminectomy.

The details of the various operations on the vertebræ and spinal cord have been left till the present section because they are all more or less alike, and are almost always begun by the removal of the laminæ of the vertebræ. This operation is variously known as lamnectomy, lamniectomy, and laminectomy. The former terms are, it is true, more correct from the philological point of view, but the last, though a hybrid of Latin and Greek, has been so generally used that I have adopted it.

The back should be cleansed in the usual way over a very large area. If the person be very hairy, of course the back should be shaved. The preparation of the hands, instruments, dressings, etc. is that usual in any ordinary aseptic or antiseptic operation.

The shock of a laminectomy is almost always severe; hence every precaution must be taken to avoid it. Dercum has therefore very properly proposed that it should be preceded by complete restfulness of mind and body; that a primary hypodermatic injection of strychnine (gr. $\frac{1}{20}$) be given; that the patient should be kept warm by a hot-water bed or hot bottles and blankets; and that atropine and caffeine be used hypodermatically, or a rectal injection of coffee be used.

Mr. Horsley has called attention to five especial dangers: First, that of hemorrhage. This is always considerable in amount, but with modern methods, and especially by means of hæmostatic forceps and pressure by sponges dipped in hot water, it is not a danger which any surgeon of experience should fear.

Secondly, difficulty in clearing the neural canal. This, too, with ordinary care, and especially after one has had experience in a few cases, as a rule, can be dismissed.

Thirdly, physical difficulties in treating the fractured vertebræ. This danger in part has already been considered. In a great many cases, of course, the vertebræ are hopelessly fractured and displaced, and cannot be dealt with satisfactorily. Unfortunately, we are not often able to judge of the severity of the fracture, excepting after it has been revealed by the operation.

Fourthly, the hopeless nature of the damage to the spinal cord. In a very large number, probably the majority, of cases of fracture-dislocation the cord has suffered so severely that its regeneration is hopeless. Even in a case, however, where the cord is almost diffluent, as in Schede's case (p. 822), occasional benefit will result even to a striking degree.

Fifthly, the danger of septic infection. With modern surgery there should not be any considerable danger of septic infection, excepting in those cases in which the fracture is compound and infection has taken place before the surgeon sees it, or in those cases in which a fistula results, especially from too prolonged use of a drainage-tube: as a rule, therefore, this should be removed within twenty-four or forty-eight hours.

Sixthly, to these dangers White has very justly added the danger of anæsthesia in the prone position, the abdominal muscles being paralyzed. This is a very real danger, and was well illustrated in one of my own cases, in which the patient came very near dying from apnœa during anæsthesia, even in the dorsal position and before I began to operate. After being etherized, however, he bore the operation very well.

As the initial hemorrhage will be rather profuse, the surgeon should not have less than two dozen hæmostatic forceps. He should also have rongeur and other bone forceps, raspatories, and, if a trephine is used, it should be a half-inch in diameter.

The patient is placed in the Sims position, requiring the administration of the anæsthetic in a most unfavorable position, especially if the injury is high up and has paralyzed the respiratory muscles excepting the diaphragm. The face should be brought to the edge of the table. The anæsthetizer's task is a most serious one, and this responsible post should be occupied only by a man of large experience, quick observation, and good judgment. Hypodermatic syringes, charged with strychnine, digitalis, and atropine, should be at hand. The patient should be well protected from chilling by blankets and by hot-water bottles, or still better by a table the top of which consists of steam-piping, so that the patient can be readily kept warm.

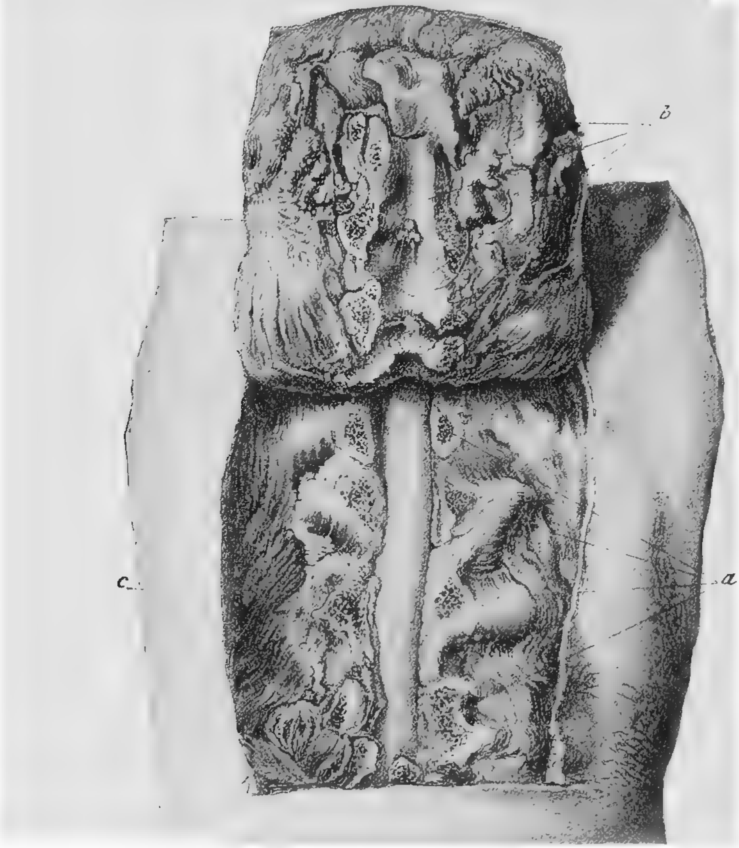
The incision is made in the middle line, four inches being the minimum, and as much longer as the extent of the operation demands. The resection should not be limited to one or two arches, but should be a large one, often involving the removal of five or six arches. I have always found a single linear incision sufficient, though incisions in the shape of T, V, or H have been proposed. Bullard, Burrell, Abbe, Dawbarn, and Urban[1] have proposed an osteoplastic resection; that is to say, that the spinous processes or arches of the vertebræ should be chiselled or bitten away from the bodies, lifted with the muscles, and replaced with the flap or flaps later. This of course requires an H or a ⊔ incision (Fig. 491). I have never found it necessary to make such an osteoplastic resection, and have been quite content with removing the arches. If an osteoplastic resection is made and the arches are replaced, their edges should be carefully rounded off, so that there would be no splinters to wound the cord.

Chipault[2] has pointed out that in a normal spine the arches are of

[1] *Archiv klin. Chir.*, xliv 1892. [2] *Gaz. des Hôp.*, Oct. 21, 1893.

little value in producing solidity of the spine, but that when the bodies are gone, as in Pott's disease, the arches replace the bodies to some extent in securing a stable spine. Pack[1] has noted a re-fracture by slight effort

FIG. 491.



Osteoplastic resection (Urban).

even a year after a laminectomy. Hence Chipault urges an osteoplastic resection, and that the stability of the spine shall be increased by suture or ligature of the spine and laminæ, and especially by a bilateral interlaminar ligature in a figure of 8. The osteoplastic operation being a long and difficult one, he proposes that it should be replaced by a subperiosteal resection, after the method of Ollier, except in tubercular disease of the arches, which is rare. He reports 6 such operations with 3 autopsies, and states that the operative result was very satisfactory.

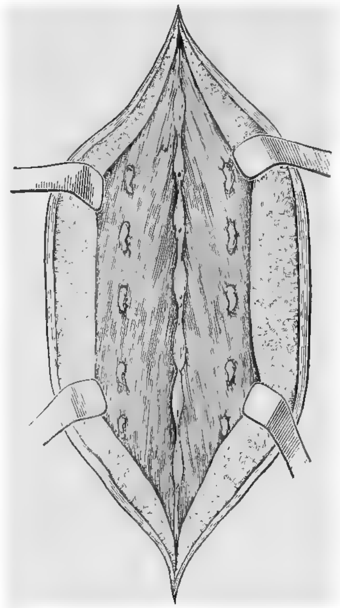
Horsley has recommended that the lumbar aponeurosis should be divided by an incision at right angles to the first, but I have never found this needful.

The muscles are first separated from the arches upon one side (Fig. 492). In doing this I have been careful to follow the advice of

[1] Chipault, *loc. cit*, p. 1145.

Horsley, not to do it with blunt raspatories, but by clean cuts of the knife. This is the more important because the spinal muscles consist largely of slips running short distances, and any blunt instrument leaves the tissue in tatters which may readily undergo necrosis. When the muscles have been well separated from the arches a raspatory can then be used with advantage to scrape away the remaining muscular tissue which still adheres to the bone, and thus to obtain a clear field of operation.

Fig. 492.



First stage in laminectomy: exposing the muscles (Chipault).

During this dissection the hemorrhage is very free, and I have found Horsley's method of dealing with it the best. Large arteries may be seized by an assistant with hæmostatic forceps, but the operator should not waste any time by attempting to do so. The more quickly he exposes the bone and packs the wound thoroughly with sponges wrung out of very hot water, as hot as can be borne by the hands of the operator, the less will be the amount of blood lost. I have usually deferred the final cleansing of the arches until after the hemorrhage has been arrested. As soon as one side has been packed the muscles are separated from the bones on the other side, and that in turn is packed. By the time that the second dissection has been made and the wound packed the first will be ready for the final clearing of the arches.

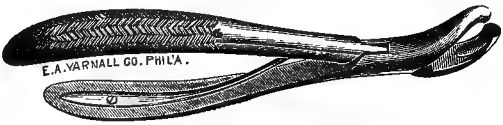
To make an opening into the canal Mr. Horsley has devised some excellent and powerful angular bone-forceps. Other surgeons prefer to use a trephine, but I have found the method described below so satisfactory that I have never resorted to other means. If the trephine be used, one edge should be placed close against the spinous processes, lest the intervertebral nerves should be wounded by the penetration of the trephine. I divide first the interspinous ligaments by a knife. Care must be taken, however, that the knife does not penetrate the canal and wound the membranes or even the cord. In the dorsal region the laminæ so far overlap each other that this is not practically a danger, but in the cervical and lumbar region it is very possible to wound the cord by a slip or too deep cut by the knife. It would seem almost needless to caution a surgeon against a possible wound of the vertebral artery if the operation is in the cervical region, but Chipault[1] states that in at least three cases speedy death has resulted from such a wound. I have not been able to find any such recorded cases.

Having thus isolated one of the spinous processes by the knife, I then quickly gnaw it away, together with a part of one of the arches, by the double rongeur forceps (Fig. 493). As soon as an opening is effected

[1] *Rev. de Chir.*, 1892, 685.

into the canal, I have found the best instrument to be the rongeur forceps which I originally devised for linear craniotomy (Fig. 494). The

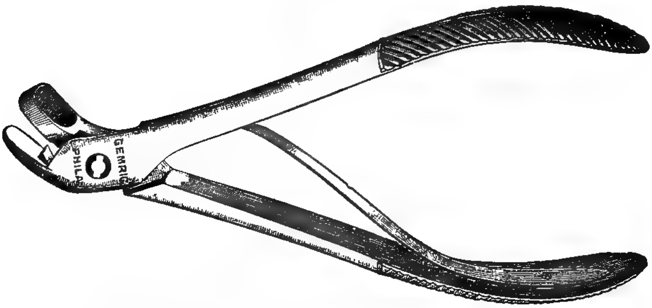
FIG. 493.



Lüer's double rongeur forceps.

chisel, of course, can be used, but I think that my rongeur forceps not only effect removal of the arches more quickly, but are much safer, as

FIG. 494.



Keen's rongeur forceps for laminectomy, linear craniotomy, etc.

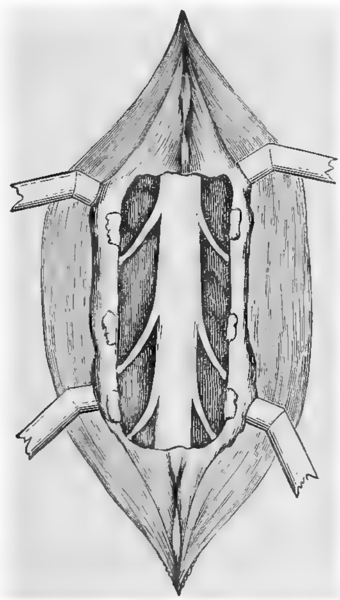
they avoid all jarring, and a slip of the chisel might wound the cord or some of the nerves. I have often found rather sharp hemorrhage from the vessels between the laminæ or within the spinal canal, especially the veins, but this is effectively controlled in a short time by pressure and hot water. The arches being removed (Fig. 495), a moderately thick layer of fatty tissue still obscures the membranes of the cord. In it lies a plexus of considerable veins which sometimes give temporary trouble, but the bleeding is again easily controlled by pressure and hot water. This fatty tissue is best treated by dividing it carefully in the middle line, pushing it to each side, and packing with small bits of sponge or gauze to produce pressure. Of course it must be carefully seen that every one of these is removed before the operation is finished.

The dura should now be inspected to observe whether it pulsates. If not, the absence of such pulsation is generally due to adhesions, swelling of the cord, or other cause of interference with the continuity of the subdural space. If there is blood under the dura, the latter will be bluish or purplish; if pus, yellowish; and if a tumor is present or there is any increase in the quantity of cerebro-spinal fluid, the increased tension and elasticity of the dura will be perceptible by touch. The membranes and cord may now be carefully drawn first to one side and then to the other by means of an aneurysm needle, the curved end of Allis's blunt dissector, a retractor, or any similar instrument, in order to expose the bodies of the vertebræ for observation or, if necessary, for operation.

Mills has proposed that if it is needful one or two nerve-roots should be divided, but this would be an unusual necessity. If it is done, however, the nerve-roots should be sutured before the operation is terminated. In order to make such observation or operation on the vertebral bodies Chipault places two cushions, some distance from each other, under the abdomen of the patient, so that the spine will be concave posteriorly, which will facilitate the displacement of the cord (Fig. 476). The nerves are sufficiently elastic to allow of moderate stretching. If any extradural tumor, thickening of the connective tissue between it and the bone, bony growth, or pressure by dislocation of fracture of the laminæ or bodies of the vertebræ or carious or necrosed bone, as in Pott's disease, is discovered, suitable treatment can now be instituted (Figs. 496, 497).

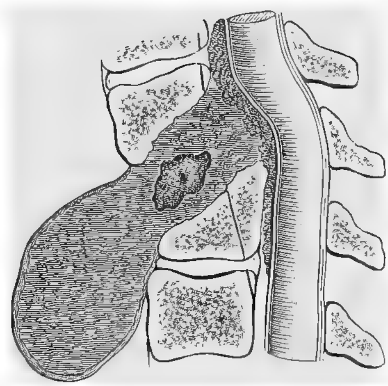
Whether the dura should be opened is a more serious question in the spine than in the brain. In the latter the opening can be closed without drainage,

Fig. 495.



Second stage in laminectomy: vertebral canal laid open (Chipault).

Fig. 496.



Pott's disease: the dark lines indicate the portion of the bodies to be removed (Chipault).

and thus we can prevent the continuous escape of the cerebro-spinal fluid. After an operation upon the spine, however, the injury to the thick muscles will sometimes prevent absolute primary union, and so favor the formation of a fistula, and the wound is so extensive and deep that a drainage-tube is usually required, and this tends in the same direction. The mere temporary escape of the cerebro-spinal fluid is not in itself so dangerous. On p. 795 a case of Robson's is referred to in which 85 ounces were intentionally removed by aspiration, and I have not uncommonly seen a large quantity lost at operation and continuously escape for some days afterward without any ill effects. But if a fistula results and the cerebro-spinal fluid escapes continuously, this is a source of annoyance and irritation to the surrounding skin and requires constant re-dressing, and has one far more serious source of danger—namely, that it is almost impossible in repeated dressings to avoid infection, with subsequent meningitis, myelitis, and often death. In spite of these objections,

however, it is generally best to open the spinal dura, and, if possible when the operation is completed, to suture it with a continuous catgut or

FIG. 497.

Pott's disease: the dark line indicates the portion of the bodies to be removed (Urban).

fine silk glover's suture in order to obtain immediate union. If the dura is not opened, we fail to learn the exact condition of the subdural space and of the cord itself.

Having opened the dura, the subdural space can be explored carefully by Horsley's dural separator or by an ordinary bent probe. It should be explored upward and downward as far as is deemed necessary. So, too, the extradural space between the dura and the laminæ should be explored, in order to determine whether there are any irregularities or obstructions, fracture, dislocation, etc. If there be a tumor on the surface of the cord, it may now be removed. If it infiltrate the substance of the cord, it is inoperable.

If the cord has been crushed or injured by accident, any splinters of bone should be removed, and any considerable irregularity due to dislocation or fracture of the bodies or arches of the vertebræ should be carefully removed by the gouge, chisel, etc. (Figs. 496 and 497).

Attempts have been made by Morris, Abbe, and Maydl to suture the cord itself, but without success. Duncan[1] has stitched its sheath above and below, but equally unsuccessfully. Leckey[2] has even gone so far as to propose to shorten the spine by removing a part or the whole of a

[1] *Edin. Med. Journ.*, March, 1889, p. 883. [2] *Brit. Med. Journ.*, Oct. 1, 1892.

vertebra or portions of two adjacent vertebræ by gouges or drills, a procedure which is only mentioned to be condemned.

The nerves when they have emerged from the cord are peripheral nerves, and should be treated by suture just as any other parts of the body.

Sometimes it is better not to suture the theca, but to leave it open. Horsley in his first case of tumor left it open for four inches, and I have done the same to nearly the same extent, my purpose being to relieve the increased pressure on the cord from its swelling, due probably to a syringomyelia (p. 849). In neither case did any ill result follow, though

Fig. 498.

Cicatrix after laminectomy for probable syringomyelia (Keen).

one might imagine that the cicatricial adhesions of the soft parts to the posterior surface of the cord might be injurious. The omission of the suture also favors the continuous escape of the cerebro-spinal fluid, which, as has been pointed out, is undesirable. In suturing it I have used the finest semicircular Hagedorn needle and a needle-holder. Both to prevent the continued escape of the cerebro-spinal fluid and also to prevent injury of the cord, no drain should be inserted within the theca. A rubber drainage-tube, however, may be placed in the muscular portion of the wound to carry off the abundant wound-fluids of the first twenty-four or thirty-six hours. Unless for very urgent reasons, the drainage-tube should not remain more than twenty-four to forty-eight hours. The muscles should be approximated by buried sutures of catgut or silk, the

skin sutured by silkworm gut, and the usual dressing applied by means of a many-tailed Scultetus bandage or an ordinary binder.

The position of the patient, which will be nearly dorsal, happily favors efficient drainage. If the escape of the cerebro-spinal fluid irritates the skin, boric acid may be liberally powdered upon it or a sterile boric-acid ointment may be applied.

After-treatment.—On account of the abundant oozing both of the wound-fluids, and possibly of the cerebro-spinal fluid, the wound will usually have to be dressed within the first twelve hours, but after the first twenty-four hours not usually more than once in two or three days. The strictest antisepsis should be observed, lest infection should follow. This is particularly necessary, both during the operation and the after-treatment, if there are bed-sores present, since they produce considerable foul discharge which may infect the wound. If the patient has lost control of the bladder and bowels, an additional source of infection exists, which will require great vigilance.

Thorburn has proposed to drain the bladder by suprapubic cystotomy after injury of the cord, to avoid the constant wetting of the wound and its infection through the incontinence of the urine. The suprapubic route is selected, inasmuch as these parts are not anæsthetic and therefore not apt to slough. The suggestion seems to be very reasonable, but I have seen no report of its having been carried into practice. The bed-sores should be dressed with boric ointment, carbolated vaseline, or other such application. They often show very remarkable early improvement, and not uncommonly heal entirely. Of course the usual precautions as to food and drink must be observed, together with the use of opiates for sleep and such other symptomatic treatment as may be required.

SURGERY OF THE NERVES.

By JOHN B. ROBERTS, M. D.

Anatomy.—Surgery, as a specialty, has little to do with any part of the sympathetic system except its ganglia in the neck and those ganglia connected with the fifth cranial nerve in the formation of which both the sympathetic and the cerebro-spinal nerves are concerned. The surgery of the nerves, therefore, is limited almost exclusively to the affections of, and operations done upon, the cerebro-spinal nerves. These nerves convey to the nerve-cells the impressions made by external excitants, and from the cells impulses of nerve-force to the muscles and secreting organs. This is accomplished by an extension of one of the processes of a nerve-cell, called the axis-cylinder, which is the centre of each nerve-fibre and its essential constituent.

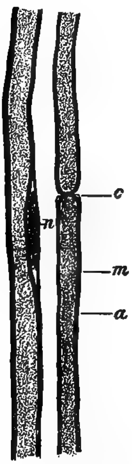
Nerve-fibres are divided into the white or medullated and the gray or non-medullated. It is the possession of a medullary or myelin sheath, often called the white substance of Schwann, which gives the distinguishing white color to the medullated fibres. The myelin sheath consists of a semifluid fatty material. Outside of this myelin sheath is the neurilemma, a membranous covering. The non-medullated fibres, or fibres of Remak, which have no myelin sheath about the axis-cylinder, belong particularly to the sympathetic nervous system, though both kinds of fibres are found in the nerves of this system, as they are in the cerebro-spinal system. The axis-cylinder in these non-medullated nerves is invested by a delicate sheath or neurilemma, which, however, is not always demonstrable.

The cerebro-spinal nerves consist principally of medullated fibres. In such nerve-fibres the axis-cylinder is surrounded by the white substance called the medullary sheath, which seems to be a sort of protector or insulator to the axis-cylinder. Outside of the medullary sheath is the membranous sheath, called the primitive sheath, sheath of Schwann, or neurilemma. In the white matter of the central nervous system medullated fibres occur in which the neurilemma is absent. Naked axis-cylinders—that is, axis-cylinders uncovered by a medullary sheath—are, however, also to be found in the peripheral nerves. The medullated nerves show constrictions at almost regular intervals, called nodes. The term internode or nerve-segment is applied to the portion of fibre between two nodes. The neurilemma and the axis-cylinder continue without interruption at the nodes, but the medullary sheath, or white substance of Schwann, ceases at the nodes. Imbedded in the medullary sheath about the middle of the internode is found an oval nucleus.

A number of medullated nerve-fibres are united into small bundles by interstitial connective tissue called the endoneurium. A number of these primary bundles are then held together by a similar sheath of con-

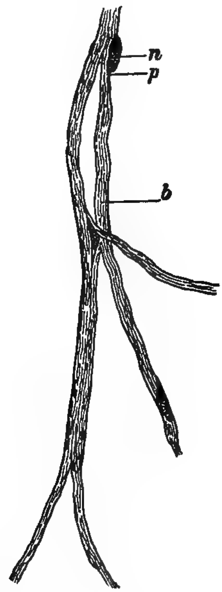
nective tissue called the perineurium. The secondary bundles are finally grouped into cords and invested by a covering of connective tissue called the epineurium. Such cords, made up of secondary bundles or fasciculi, constitute the "nerves" with which we deal in surgery. The sheath

FIG. 499.



Medullated nerve-fibre: *a*, axis-cylinder; *n*, nucleus; *m*, medullary sheath; *c*, node of Ranvier.

FIG. 500.



Non-medullated nerve-fibre: *n*, nucleus; *b*, striations.

investing these fibres, the epineurium, sends septa between the sheaths of the secondary bundles. The small blood-vessels, lymph-spaces, and the minute nerves which supply the nerve-cords themselves are contained in the septa and sheaths connected with the epineurium. The nerves of a nerve are derived from the nerve itself; that is, its nervous supply comes from fibres in its own trunk.

The nerve-fibres which convey impressions from the periphery and sensory organs to the nerve-centres are termed afferent, centripetal, or sensory; while those which conduct impulses from the nerve-centres to the muscles and secreting structures are called efferent or centrifugal fibres. The term "motor" is also used when they innervate muscles. There is no clear anatomical difference between these two kind of fibres.

DISEASES OF THE NERVES.

ANÆMIA AND HYPERÆMIA.

Anæmia of a nerve may be the cause of neuralgia. It occurs in general anæmia and in nervous affections causing vaso-motor spasm, as well as from those pathological states which result in obstruction of the current in the blood-vessels. Obliterating arteritis gives rise to this de-

crease in blood-supply, and may therefore be the cause of neuralgia. This painful affection in the aged is probably quite often due to anæmia, since in such persons this form of arteritis is not unusual.

Hyperæmia results from affections causing paralysis of the vaso-motor nerves, from rheumatism, gout, metallic and other poisons, nerve-injuries, inflammation of the surrounding structures, and from exposure to cold. It also may give rise to neuralgia. Both of these alterations in the blood-supply to the nerves are secondary conditions. Their symptoms are not very definite, and therefore the exact pathological condition is often difficult of clinical demonstration. The neuralgic pain will, however, lead in many instances to an investigation of the general condition of the patient. Such an investigation will probably conduct the surgeon to a correct diagnosis of the state of the nerve-structures. The symptoms which point to hyperæmia are numbness, burning, tenderness, pain, and other sensory symptoms, perhaps, associated with muscular weakness. Anæmia of a nerve can scarcely be demonstrated by any special clinical symptoms. Its diagnosis is made by exclusion.

The **treatment** of anæmia and hyperæmia will depend upon the cause. Local abstraction of blood, the application of ice, counter-irritation, and cupping may be valuable in hyperæmia. Massage, mercury, potassium iodide, iron, and nitro-glycerin have been recommended. The part should be kept at rest and remedies similar to those used in mild neuritis should be tried. In anæmia remedies to relax vaso-motor spasm and overcome the causes of obstruction in the blood-vessels are indicated. General tonics are eminently worthy of trial.

DEGENERATION.

When nerve-fibres are separated from their cells of origin they undergo degeneration. This degeneration occurs in both medullated and non-medullated fibres, but more is known of the process in the former than in the latter. The fibres lose their myelin sheath and axis-cylinder, and after a time those which have thus died are represented by mere strands of ordinary connective tissue. Destruction of the trophic centre of the fibre, separation of the nerve from this centre, the direct action of toxic agents, inflammation, or actual mechanical destruction of the nerve-fibre itself are the usual causes of degeneration. The peripheral portion of a nerve supplying a muscle may become the seat of a primary degeneration as the result of the muscle being unused and undergoing atrophy. Degeneration is usually, however, secondary to other pathological conditions of the nerve itself.

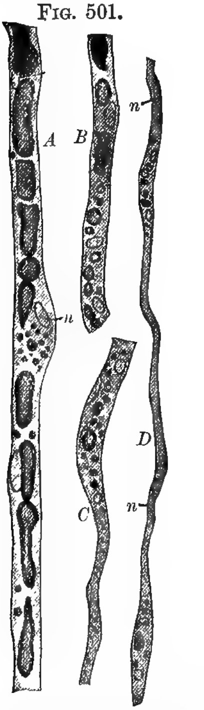
The **symptoms** are enfeeblement of function, occurring sometimes rapidly, at other times slowly, and often leading to its complete loss, pain, spasm, paralysis, anæsthesia, and trophic and vaso-motor disturbances, exhibited in the regions supplied by the nerve undergoing degenerative change.

Of the three forms of nerve-degeneration described, but one is of special interest to surgeons. This is the so-called Wallerian, or secondary, degeneration. Primary degeneration and the toxic degeneration which occurs in association with neuritis are less important to the surgical practitioner, though of great interest to neurologists.

Primary degeneration is rare, limited in extent, and consists of a simple atrophy and disappearance of the myelin sheath and axis-cylinder. It is found in locomotor ataxia and wasting diseases. Neuritic or toxic degeneration attacks the nerves in segments. The axis-cylinder is not so much affected as in secondary, or Wallerian, degeneration, and the myelin breaks up into very small drops of fat rather than into larger drops or masses.

Secondary degeneration takes place when nerves have been compressed, over-extended, or divided; or destroyed by tumors, injuries, or inflammation. When thus cut off from their trophic cells the fibres begin to degenerate throughout the length of the nerve. The process is completed in two or three weeks, but loss of the nerve-function takes place in a couple of days. The degeneration takes place in the direction in which the nerve-impulse passes, except in peripheral afferent nerves. The myelin sheath and its nuclei undergo alteration first; the axis-cylinder subsequently undergoes change, and then the neurilemma is affected. The myelin becomes turbid and breaks up into drops. The axis-cylinder similarly separates into fragments and is liquefied. During this process the nerve shrinks in size and becomes more or less translucent and of a grayish or grayish-red color. The process ends in atrophy of the nerve-fibres, which become fibrous cords.

FIG. 501.



Four degenerating cutaneous nerve-fibres (Pitres and Vaillard): *n*, *n*, represent the nuclei. In *A* protoplasm and nuclei increased; myelin breaking up; degeneration is more advanced near nucleus in middle of fibre than elsewhere. In *B* segmentation has gone on to formation of globules. In *C* globules are small, and many have been removed, so that fibre is narrow. In *D* degeneration has greatly advanced, and products have been removed from a large portion of the sheath.

The fibres of the portion of divided nerve connected with the cerebro-spinal axis are affected as far as the first or second node of Ranvier. Disuse may subsequently cause further degeneration of the central stump. The degeneration occurs throughout the whole length of the nerve about the same time, though the motor end-plates in the muscles show the degeneration a little earlier than other portions of the nerve. The cut ends of a divided nerve become bulbous. These bulbous masses are made up of nerve-fibrils and connective tissue. The degeneration goes on, as a rule, in the direction in which the nerves carry impulses, but the peripheral sensory nerves are an exception in this respect, for they may degenerate also at the distal side of the injury. The peripheral ends of a divided nerve lose nearly all their fibres as far as the termination of the nerve. A few fibres degenerate in a central direction as far as the cord itself. These are the afferent fibres which have their trophic centres in the periphery. It is these fibres which are found to resist degeneration in the peripheral part of the nerve. When section is made between the spinal ganglia on the posterior root of the spinal nerves and the cord, degeneration does not occur in a

peripheral direction. This is because the spinal ganglia are the trophic centres for most of the sensory fibres. In the other direction the degeneration proceeds to the cord, and even into its structure. Simple division of a nerve seems less likely to lead to extensive degeneration than a contusion which causes extensive displacement of the myelin. If the cut ends of a nerve are quickly approximated, degeneration seems not very likely to occur; in the lower animals it certainly does not occur. Wallerian degeneration may be looked upon as a sort of parenchymatous inflammation.

The symptoms and electrical reactions of secondary degeneration will be discussed under Injuries to Nerves.

REGENERATION OF NERVES.

Nerve-fibres which have undergone degeneration frequently have their function completely restored by a process of regeneration. Nerve-tissue is the only specialized tissue which is so restored after destruction. For this regeneration to occur the trophic centre must be healthy and the mechanical obstacles to repair not too great. When the degeneration has resulted from division of the nerve, regeneration is more apt to occur if the cut ends have been carefully apposed or have not been allowed to remain separated for too many months. If complete atrophy has not occurred in the peripheral end, restoration is more successfully accomplished. Regeneration appears to occur only in the peripheral nerves, and not in the fibres of the central nervous system. The reconstructive process in nerve-fibres is slow. It may be completed in a few months or require a year or more; the length of time depends upon the amount of nerve destroyed and the completeness of the degeneration. Repair progresses from the central portion of the nerve toward the periphery. If the nerve has been divided, the axis-cylinders in the central stump swell, divide into new axis-cylinders, and gradually grow across the interval. If no division of the nerve has occurred, the fibres of the central portion grow out into the degenerated peripheral fibres.

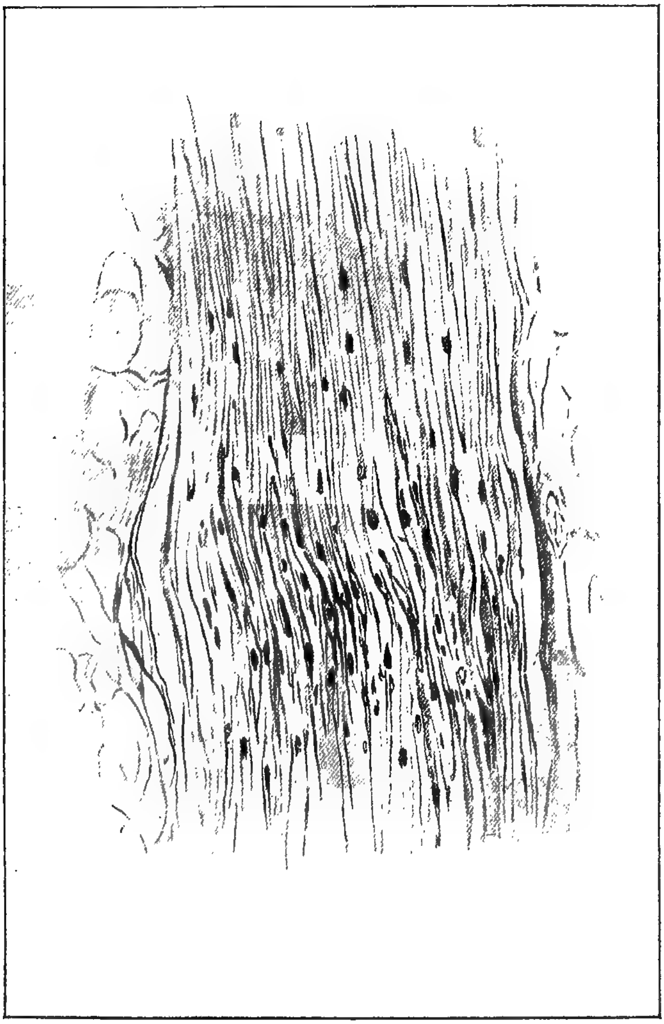
Bowlby asserts that regeneration may occur in the peripheral end of a divided nerve when there is no union between it and the central end. He says that new axis-cylinders are developed from the nuclei of the sheath of Schwann or neurilemma, and become surrounded with myelin. These new fibres, which develop from the peripheral end, tend to degenerate again if union with the central end is not finally accomplished. The experimental observations of Ranvier and Vanlair seem opposed to this view.

When new fibres are developed from the axis-cylinders in a portion of damaged nerve, more than one new axis-cylinder may proceed from a single axis-cylinder. The process is a slow one, but in the lower animals the new fibres will grow through a considerable length of cicatrix in the endeavor to unite the extremities of a divided nerve which have not been approximated. It is doubtful whether regeneration with complete restoration of function of a severed nerve occurs in man unless the extremities of the fibres are placed in contact or at least brought comparatively near to each other. As would be expected, restoration of function in degenerated nerve-fibres occurs more readily when the origi-

nal injury has been slight, and has therefore resulted in a moderate degree and extent of degeneration.

The muscles which are supplied by motor nerves undergo degenera-

Fig. 502.



Longitudinal section through the lower end of a divided nerve nine months after section, showing the early formation of new nerve-fibres from the nuclei of the sheath (Crouch, ⅛ in.) (Bowlby).

tion and atrophy coincident with the degeneration of the nerves. The muscular fibres become narrower, cloudy, granular, and fatty, and their transverse striation becomes less distinct. The muscular fibres are finally separated by increased connective tissue, producing a cirrhosis, and ultimately are substituted by fibrous tissue which undergoes contraction and produces a shortening of the muscle. If the damaged nerve is regen-

erated, the damaged muscle also gradually returns to its normal condition, but in many instances there remains a permanent increase of

FIG. 503.

Longitudinal section of the lower end of a divided nerve nine months after section, showing bundles of newly-formed nerve-fibres under a low power (Crouch, ½ in.) (Bowlby).

connective tissue in the muscular mass. The muscle then remains permanently smaller.

NEURITIS.

Definition and Varieties.—The term "neuritis" is employed to indicate inflammation of the peripheral nerves. It is sometimes defined as an inflammation of nerve-fibres. This restriction is scarcely correct, as in some forms of neuritis the pathological process is limited almost entirely to the connective tissue forming the perineurium and endoneurium.

Inflammation affecting a single nerve is called isolated or localized neuritis, and is the form with which surgeons are particularly concerned. Multiple neuritis, or polyneuritis, is that form which attacks a number of nerves simultaneously. It is characterized by a wasting and painful paralysis or by ataxic symptoms associated with muscular weakness. It is apt to be subacute, and shows inflammatory and degenerative changes, beginning in many of the peripheral nerves at the same time. It is caused by the poisons of infectious diseases, such as diphtheria, typhoid fever, scarlet fever, small-pox, and leprosy; by poisons, such as alcohol, ether, bisulphide of carbon, lead, arsenic, mercury; by various cachectic conditions, such as anæmia, tuberculosis, and malignant tumors; and occasionally by exposure to cold and wet and by great physical exertion. Beri-beri is an endemic multiple neuritis probably due to a micro-organ-

ism. In this country chronic alcoholism and diphtheria are probably the commonest causes of multiple neuritis.

Localized neuritis may be acute, subacute, or chronic; non-traumatic or traumatic. The acute form ordinarily becomes chronic before cure is effected. Nerve-trunks may at times be exposed to a considerable degree of injury without becoming actually inflamed. Aseptic wounds, as would be expected, cause little irritation. Localized as distinguished from multiple neuritis usually begins in the outer sheath or perineurium, and is therefore a perineuritis. If it involves in addition the connective tissue between the bundles of nerve-fibres, it is called an interstitial neuritis. Both of these forms may properly be denominated adventitial neuritis. Inflammation of the nerve-fibres themselves is properly called parenchymatous neuritis, and is sometimes termed degenerative neuritis. The inflammatory process may spread along the nerve, constituting, if it goes toward the nerve-centres, an ascending or migratory neuritis. A descending neuritis may also occur.

Causes.—Some persons may be predisposed to inflammation of the nerves, which then occurs from very slight excitants. Exposure to cold is not an infrequent exciting cause of neuritis of the facial and other nerves. Rheumatism, syphilis, and perhaps gout, may give rise to inflammatory conditions of the nerves. Some cases of so-called muscular rheumatism with wasting of the muscular tissue are probably instances of motor neuritis. Extension of inflammation from surrounding tissues can cause neuritis in adjacent nerves. This has been known to occur in the nerves situated near a large bed-sore. Neuritis of the facial nerve where it goes through the aqueduct in the temporal bone may arise as a result of caries of that bone. Interstitial neuritis has been seen in the neighborhood of malignant tumors, independent of such neuritis as occurs when a nerve is actually infiltrated with tissue-elements characteristic of malignant disease. Syphilitic lesions, arthritis, and bone disease may in a similar way be the cause of inflammation of the nerves in the vicinity.

Traumatism is a cause of neuritis not infrequently brought to the attention of the surgeon. Incised and punctured wounds, contusions, lacerations, and over-stretching of nerves occur and set up inflammation. Dislocations and fractures and the efforts to reduce such bony displacements may be accompanied by nerve-lesions and by consecutive inflammation. The callus thrown out in Nature's attempt to unite a fracture may make injurious pressure upon entangled nerves. Hypodermic injections of ether or other substances may cause inflammation of a nerve, which may be injured by the point of the needle or by contact with the irritating fluid. Violent voluntary contractions of muscles through which nerves pass are a possible cause of the affection under consideration. Injuries and mechanical strains of fibrous tissues, fasciæ, and muscles may cause in these structures an inflammation which subsequently spreads to the nerves. Suppuration in joints is a possible cause of neuritis, and non-suppurative meningitis not infrequently causes a secondary neuritis of the cranial and spinal nerve-roots.

Pathology.—The pathological changes in neuritis differ according as the connective tissue or the nerve-fibre itself is affected by the inflammatory process. In perineuritis or interstitial neuritis the nerve is usually

swollen, infiltrated, and red. Lymphoid elements, or corpuscles resembling leucocytes, infiltrate the sheath and the prolongations of the sheath between the bundles of nerve-fibres. Extravasations of blood may be seen, and the vessels are so distended that they give rise to a pink or reddish color of the nerve-trunk. These changes are diffused continuously along the nerve or limit themselves to foci or disseminated spots. The latter form is often called segmental neuritis to distinguish it from the former or diffuse neuritis. The inflammatory process will probably be most evident where the nerve perforates a canal in bone or fascia, or where it divides into branches or makes a bend in its course. The fibres are not very much affected in this connective-tissue form of neuritis, unless pressure is made upon them by the inflammatory exudate. Such pressure is most apt to occur at points where the nerve is enclosed in a bony or fibrous canal. Under this and some other circumstances there is, however, some change in the fibres themselves. This alteration is shown by an increase in the nuclei of the neurilemma, breaking into fragments of the myelin, swelling of the nuclei of the internodal cells, and varicosities and granular degeneration of the axis-cylinders. The nerve-fibres may finally be entirely destroyed, leaving only the fibrous connective tissue, in which an unusual amount of fat is often found. The fibrous tissue at times is so increased that a sclerosis of the nerve results. Fusiform swellings, adherent to the surrounding structures, occasionally remain as a result of the inflammation. The serum, lymph, and leucocytes which infiltrate the nerve may, if pyogenic germs gain access to the inflamed area, become pus. Similarly a gangrenous neuritis is possible.

In parenchymatous neuritis the changes in the nerve-fibre are similar to those seen in Wallerian degeneration, already spoken of as a parenchymatous degeneration. Here the force of the inflammatory process is first exerted upon the nerve-fibres. The myelin breaks up into small globules and granules, the axis-cylinders are destroyed, the neurilemma becomes empty, and its nuclei increase in numbers. The connective tissue between the fibres is affected but little and only secondarily. The muscles to which the nerves are distributed become atrophic.

It is an interesting fact that tubercular and syphilitic neuritis seem to be almost entirely limited to the intracranial portions of the cranial nerves and to the spinal nerve-roots. The neuritis is usually secondary to a tubercular or syphilitic meningitis.

Symptoms.—The constitutional symptoms are usually slight, and, if present, often subside before the local symptoms become marked. The local symptoms vary with the extent and intensity of the inflammation and the character of the nerve involved. The nerve may be motor, sensory, or mixed, or a nerve of special sense, and the modifications of function due to the inflammation vary accordingly. Neuritis is not very apt to run a short course; it commonly lasts for weeks. The symptoms gradually subside as the disease assumes a chronic type. Traumatic neuritis improves more quickly than inflammation of a gouty or rheumatic etiology. It should be recollected that an ascending neuritis occurring in the course of a limited traumatic neuritis may seem like a new inflammation, because its symptoms show themselves at a spot some distance from the original lesion.

The first effect of neuritis is an increased irritability of the nerve; it is likely to be succeeded by a diminution of nervous excitability. If the nerve be motor, the period of invasion will be marked by twitching and spasm of the corresponding muscles, followed by more or or less impairment of muscular power. The muscles become weak and tender, and show fibrillar twitching or perhaps clonic spasm; but they are seldom powerless, though pain may prevent their voluntary contraction. Contractures may finally occur. When tested by electrical currents the muscles will show changes varying with the character of the neuritis. The reaction of degenerated nerve-supply, due to degeneration of the terminal nerve-fibres and motor end-plates in the muscles, is not unusual. In this reaction of degeneration the nerve fails to give muscular response to the static, faradic, or galvanic currents, and the muscle itself responds only to the galvanic current, and with a peculiar sluggish tetanic contraction which is more marked when closure of the current is made with the anode or positive pole than with the cathode or negative pole. Atrophy of the muscles also occurs.

The first symptoms of neuritis affecting a sensory nerve are apt to be numbness, pricking, and tingling, referred to the peripheral distribution of the nerve. Subsequently hyperæsthesia, and still later analgesia and anæsthesia, occur. Pain, when present, is of a boring character, rarely darting, and is experienced along the course of the nerve and at its distribution. It is remittent rather than intermittent, is increased by movement and by pressure or tension on the nerve, and is worse at night. Coughing or any other factor causing passive congestion of the parts will increase the suffering. The pain may be of the burning character to which the name "causalgia" has been given. Reflected pain may be experienced in the corresponding part of the opposite limb or of the other side of the body. The very bone may seem tender, and be suspected as the seat of inflammation until pressure on the nerve proves it to be the seat of disease. Reflex influences may cause muscular spasm to accompany sensory neuritis. This occurs at times in neuritis of the trifacial nerve. Pain may exist in the peripheral distribution of an inflamed nerve even though the skin is anæsthetic. Neuralgic pains may persist for some time after cure of a neuritis, because a sort of over-action has been developed in the nervous centres.

The cranial nerves offer a good opportunity for the differential study of motor and sensory neuritis. The spinal nerves, being mixed, show when inflamed various combinations of motor and sensory symptoms. If the inflamed nerve is superficial, the skin covering it may be hot, red, and œdematous, and the nerve may be felt by palpation as a hard, sensitive cord under the integument. Reflex excitability and electric contractility become decreased as the pathological condition of the nerve becomes established.

Ascending neuritis, which is by no means rare, causes a gradual extension of the symptoms. When the inflammation ascends to a plexus of nerves, it may spread along several or all of its ramifications. The disease may continue its upward course until it reaches the spinal canal, where it can induce meningitis and myelitis, and even cross the cord and descend along nerves on the opposite side. As has been intimated above, symptoms may appear on the side opposite to the original

disease. This occurs at times without cord implication, by an apparent sympathetic involvement not understood.

The trophic symptoms which occur in both acute and chronic neuritis are extremely interesting. The epidermis of the parts supplied by the affected nerve may become thickened, so that the skin resembles that seen in ichthyosis. On the other hand, it may become atrophied, giving rise to glossy skin. In some cases an herpetic eruption or ulceration occurs. The nutrition of the nails of the fingers and toes is often impaired, and they become curved, ridged, and fibrous. Occasionally a local increase of perspiration is observed, and sometimes the perspiratory secretion is diminished or arrested. The subcutaneous tissue becomes œdematous. Atrophy and contracture of muscles result from the defective innervation of these structures. Effusion into joints, and even adhesions, occur, so that the articulations may become fixed in the positions assumed because of the pain. Savory, Butlin, Bowlby, and perhaps others have recognized neuritis in the tibial nerves in cases of perforating ulcer of the foot, though it is possible that all cases of this disease are not due to either peripheral or central neuritis.

Neuritis is believed by Bowlby to be associated in some way with the gangrene which occurs in diabetics, though possibly it is only the predisposing cause of the destruction of tissue. The ulcerations and gangrene which form part of the clinical history of leprosy are not improbably similarly associated with inflammatory nerve-changes. It is well known that the anæsthesia and loss of muscular power occurring as symptoms of leprosy depend upon nerve-changes. The peripheral gangrene occurring in Raynaud's disease, and the symptoms in the rare affection to which the name of Morvan is given, are trophic lesions associated, in some cases at least, with neuritis. It is true that the neuritis may be secondary and not causative. In Morvan's disease there is a slowly progressive paralysis and atrophy of the hands and feet, with analgesia and the occurrence of painless felons, with perhaps actual necrosis of the bones of the digits.

Traumatic neuritis is probably more readily cured than secondary inflammation of a nerve consequent upon suppuration. The intensity of the symptoms and the occurrence of progressive degeneration aid the surgeon in coming to a decision as to the prognosis of the disease. As has been stated, pain often lasts for a long time after the cause has been removed, and nerve-regeneration does not take place until weeks or months have elapsed. Patients with a neurotic diathesis recover more slowly than others.

Diagnosis.—The differential diagnosis between neuritis and neuralgia is important. It is especially difficult in chronic neuritis, because many conditions frequently called neuralgia are really cases of neuritis. The pain of neuritis is distinguished from that of neuralgia by the remittent character of the latter. The suffering in neuralgia is, as a rule, intermittent, and the points of tenderness are more uniformly localized. Neuralgia does not give the local elevation of temperature, the muscular spasms, the paralysis, and the paræsthesias which belong to neuritis. The trophic lesions resulting from the latter are not to be expected in the former affection. Pain and tenderness are found in the line of the inflamed nerve, though the diffuse character of the pain in the beginning

of neuritis may simulate rheumatism, ostitis, or periostitis. Pain due to disease of the spinal cord is not localized in a single nerve-trunk, and there is not the same tenderness when pressure is made over the nerve.

These characteristics will serve to clear up the diagnosis between central disease and neuritis in most surgical conditions; but the difficulty of diagnosis is greatly increased when cases of multiple neuritis, such as come under the observation of physicians, are to be distinguished from central lesions.

Treatment.—In the treatment of no disease is a correct appreciation of the cause more essential than in neuritis. Syphilitic neuritis requires mercury and potassium iodide; rheumatic neuritis, salicylic acid or its compounds, alkalies, and quinia; while gouty neuritis will be best managed by a resort to colchicum and diuretics in combination with alkalies. The prevention of pyogenic contamination of wounds and the early establishment of an aseptic condition are the important objects to be obtained in inflammation of a nerve due to local suppuration. Absolute rest of the affected limb, accomplished by putting it upon a splint, elevation of the part, and the envelopment of it in cotton to prevent cutaneous contact, are demanded in acute cases. Hot lotions and fomentations containing belladonna and anodynes, local bloodletting, and deep injections of morphia, atropia, and chloroform have been resorted to with satisfaction. Phenacetin internally administered has some reputation for relieving the pain of neuritis.

After the acute inflammation has subsided, and in cases where the disease has been more or less subacute from the start, galvanism may be resorted to with some hope of giving comfort. The galvanic current is said to be more beneficial than the faradic current, and should be weak when first employed. Diuretics, diaphoretics, and laxatives should be used to meet general indications. Morphia, the bromides, chloral, sulfonal, and hyoscine will frequently be demanded to relieve the excruciating pain. Cocaine by hypodermic injection at the seat of pain is a wiser remedy for relieving the suffering of neuritis than morphia. The former has direct action upon the nerves affected, while morphia acts only by blunting the sensibility of the brain. Both remedies are liable to produce habituation if not used with great discrimination. The morphia, of course, has greater power to relieve intense pain than cocaine. The faradic current should not be used in acute neuritis. It is said to do actual harm. Hot applications, moist or dry, sometimes give comfort to the patient. Ice locally employed is occasionally serviceable, particularly in traumatic neuritis.

Chronic neuritis should be treated with the constitutional remedies above mentioned, as especially indicated in syphilitic, rheumatic, and gouty cases. Counter-irritation by blisters and the actual cautery will at times aid in the cure. Injections into the nerve-trunk itself of chloroform or of a 1 per cent. solution of osmic acid have given relief.

Tonics—and among these strychnia especially—are good remedies. Change of residence will often aid in hastening cure. For the atrophied muscles galvanism and mild massage are indicated. In the use of counter-irritation it must be remembered that the anæsthesia resulting from the neuritis may prevent the patient complaining of pain from the

mustard or other stimulating applications employed. Troublesome burns are sometimes due to neglect of this precaution.

Nerve-stretching is an operation which has been much resorted to by surgeons for the cure of neuralgia and chronic neuritis. Its mode of action is not well understood, and the beneficial result expected is often not obtained.

NEURALGIA.

Definition.—The term "neuralgia" is used when pain occurs in the course of one or more cerebro-spinal nerves which cannot be accounted for by inflammation or other discoverable organic change in the nerve. The name is often incorrectly applied to neuritis, sclerosis of nerves, pressure from tumors, and other pathological conditions which are considered to be neuralgic or functional because the surgeon has not been able to determine that a pathological lesion is actually present. The progress of medical science has greatly limited the number of cases to which the name neuralgia can properly be applied.

Varieties.—As neuralgia, speaking strictly, is pain in a nerve without discoverable organic lesion, all true neuralgias may be called spontaneous or idiopathic neuralgias. Various terms, founded on the cause, are used to express the different kinds of neuralgia; as, for example, hysterical, reflex, traumatic, gouty. The use of these descriptive adjectives is evidence of the clinical confusion between neuritis and neuralgia. The very violent form which occurs in the fifth cranial nerve is often called epileptiform neuralgia, because the paroxysms of pain are much more sudden and intense than the intermittent paroxysmal pain ordinarily seen in neuralgia of other nerves. Prosopalgia and tic douloureux are terms also used to designate this form.

Erythromelalgia, also called congestive neuralgia and red neuralgia, is a chronic painful condition occurring in the feet and hands, associated with dusky or mottled redness of the skin, and is apparently due to a neuritis.

Megrim or hemicrania, and headaches are not classified with the neuralgias.

The situation of the neuralgia is indicated by mentioning the nerve affected; for example, trigeminal neuralgia, sciatic and visceral neuralgia. Unfortunately, the word is frequently employed to cover careless diagnoses. The pain of stone in the bladder, of scybalous masses in the rectum, or of anal fissure has often been attributed to neuralgia of the bladder or rectum. Coccygodynia, or neuralgia at the coccyx, may be a functional condition, but anal fissure should always be suspected and sought.

Metatarsalgia, or Morton's neuralgia of the foot, which has for its prominent symptom pain in the metatarso-phalangeal joints of the third and fourth toes, is possibly a neuritis due to pressure on the external plantar nerve by partial luxation of the joints. It may be a true neuralgia.

Tarsalgia has been applied to pain of an uncertain cause in the feet of those compelled to stand and walk a great deal. It is probably due to incipient flat-foot.

Neuralgia more frequently attacks the trigeminal, sciatic, and intercostal than other nerves.

Causes.—A neurotic constitution, inherited or acquired, anæmia or general debility, gouty and rheumatic tendencies, diabetes, and toxic agents, such as alcohol, lead, and arsenic, predispose to neuralgia. Malaria has been supposed to be a fruitful cause of this disease. Some recent authorities believe that the intermittent character of neuralgic paroxysms has caused observers to give more credence than is proper to this opinion. It is possible that the curative power of quinine and arsenic is due to the effect of these drugs as tonics rather than as anti-malarial agents.

Neuralgia occasionally occurs at the beginning of typhoid fever and other acute diseases, but it can hardly be said that these affections are its cause. Neuralgia is more common in women than in men. It does not affect young children, and is rather rare in old age, except in the form described as epileptiform neuralgia of the fifth cranial nerve.

Over-exertion, emotional shock, injuries, toxic agents, and various infections are believed to be exciting causes of neuralgia. It is difficult to distinguish with certainty between neuralgia and neuritis so caused. Local irritation of a nerve may produce neuralgia of the nerve so irritated, or of some other nerve by reflex influence. Injuries may perhaps cause neuralgia without setting up a neuritis. Tumors outside the nerve or within the nerve, periosteal thickening, foreign bodies such as bullets, fractures, and dislocations, may cause neuralgia by pressure on the nerve-fibres. It is probable that inflammatory exudates in the nerve-sheath and varicosity of the blood-vessels supplying the nerve induce neuralgia in this manner. Persons running sewing-machines, and blacksmiths, who are subjected to long standing and the carrying of heavy weights, are supposed to be more liable than others to sciatic neuralgia. Occupations which render persons liable to sudden changes of temperature and over-use of muscles seem to predispose to this disease. Exposure to cold causes a neuralgia or neuritis not well understood. Cicatrizing wounds are occasionally the seat of great pain, because of pressure exerted upon nerve-filaments caught in the granulation tissue. Such neuralgias often come under the notice of surgeons for excision of the tender scar.

Irritation of peripheral nerves is a not infrequent cause of reflex neuralgia. A carious tooth will give rise to nerve-pain in the fifth cranial nerve. Pain in the neck and arm may be due to an irritated nerve of the lower extremity. Stone in the kidney can cause neuralgia of the testicle by irritation of a branch of the nerve whose terminal branches supply the testicle. These are illustrations of reflex neuralgia.

It must not be forgotten that neuralgia may be due to organic disease of the brain and spinal cord. Cerebral and spinal tumors and inflammations are thus concerned in the etiology of nerve-pain. Spinal caries is a surgical condition to be thought of in this connection.

The neuralgias occurring in anæmic and dyspeptic individuals and in those exhausted by over-work and anxiety are not surgical in their aspect, but they must be remembered, lest unnecessary operations be done. Their cure can be secured by judicious exercise, good food, hygienic surroundings, and medicinal treatment.

Pathology.—Disease of the sensory nerves, of the nerve-sheaths, or impaired nutrition of the nerve-trunk, due to obliterating arteritis or senile sclerosis, may be the pathological lesion in neuralgia. In cases where the nerve-pain quickly changes its location from one nerve to another no pathological alteration is discoverable. It is not impossible that in such cases the lesion is in the spinal ganglia or sensory cells of the posterior roots of the spinal cord.

Sometimes the neuralgic pain survives after the cause has been removed and the pathological change has disappeared. Such reminiscent neuralgias arise from the existence of a pain-habit, and seem to be especially prominent in patients who have used opiates extensively during the original disease. If the pathological findings of neuritis are discovered, the disease is not properly called neuralgia. The intracranial portions of the second and third divisions of the trigeminal nerve, removed by me for intractable tic douloureux some years ago, showed, according to the pathologists, these conditions: "The cells of the neuroglia are in several localities undergoing proliferation, not a few having centres of an almost embryonic condition. The blood-vessels of the nerve are not, however, varicose, tortuous, or saccular. The cylinders are advancedly degenerated, many cylinder-sheaths being void of any semblance of a central cylinder. This degenerating process is not universal in any one tubule, as at points almost normal remains of the tubule may be seen. By this we mean points at which the cylinder appears histologically normal."

Symptoms.—The characteristic symptom is darting pain of great intensity, occurring in paroxysms and radiating from a point more or less localized along the distribution of one nerve. Between the paroxysms there may be no pain or a dull aching sensation. Pressure upon the nerve where it makes an exit through the deep fascia or a bony canal may increase the burning, shooting pain, but otherwise firm pressure is generally not painful. Sometimes, however, the skin is hyperæsthetic and the nerve tender. The paroxysms and intermissions of pain may be very regular, even in cases not of malarial origin. Neuralgia shows a tendency to be unilateral, and is often worse at night. The pain may be somewhat diffused, and, instead of being confined to one nerve, may appear in several nerves successively. The application of heat, cold, or pressure may instigate a paroxysm during the intermission or remission.

Tenderness over the spine corresponding to the place of origin of the nerve has been observed. Numbness, coldness, tingling, and heaviness of the limb, muscular spasm and weakness, and various vaso-motor, secretory, and trophic symptoms may occur. These symptoms should suggest neuritis to the observer. Herpes zoster occurs in connection with neuralgic pain, but here the nerve is inflamed and the condition is not truly a neuralgia. Patients subject to neuralgia are apt to suffer from repeated attacks, varying in duration from weeks to months.

The violent form of neuralgia, called tic douloureux or epileptiform neuralgia, which occurs in the fifth cranial nerve, has symptoms that often demand surgical interference. The disease occurs in both sexes and in varying ages and constitutions. The patients are not necessarily debilitated, though the violence of the pain so interferes with sleep and with mastication and deglutition that their nutrition may be impaired.

The paroxysms of pain, which may affect any one or all three of the divisions of the trigeminal nerve, are sudden and startling in their character. The excruciating pain lasts from a few seconds to half a minute, and the paroxysms may be repeated many times with scarcely an interval. Occasionally reflex spasm of the muscles occurs with each exacerbation of pain. A breath of cold air, or attempts to speak, swallow, or chew, or the slightest touch to the surface of the face, may be sufficient to excite a spasm of agonizing pain. It usually begins at a single spot and radiates over the distribution of the nerve to the skin. The patient seems to lose self-control, grasps his head with his hands, clenches his teeth, and sometimes writhes in agony. The pain is felt in the mucous membrane of the gums, lips, and nose, as well as in the skin of the face. The secretion of tears and saliva is frequently increased. The dread of having such paroxysms excited makes the patient exceedingly timid in speaking, eating, and drinking, and gives him a cautious demeanor which is quite characteristic. In some cases friction over the tender spot seems to lessen the pain. Patients with supraorbital neuralgia may for this reason rub off the hair of the eyebrow in their attempts to gain comfort. Such relief is probably given only when the pain is of moderate severity, for in severe cases touching the skin seems to cause intolerable suffering, and may even start a paroxysm when it has been previously absent.

Patients may recover from an attack of epileptiform neuralgia after suffering for some weeks, and be free from pain for a period of months. Other attacks, however, usually occur, and the disease is exceedingly rebellious to treatment. The suffering is so great that the patient may commit suicide. Patients are nearly always willing to submit to repeated surgical operations, asserting that any risk is preferable to the agony which they are compelled to endure.

Diagnosis.—The pain of neuralgia is similar to that of neuritis, but the latter is less paroxysmal and more likely to be accompanied by anæsthesia, loss of power, and tenderness over the nerve-trunk. Sensations of coldness and of burning are more probably due to neuritis than to neuralgia. On the other hand, paroxysmal pain following the course of the nerve, and accompanied by tender spots where the nerve is known to perforate fascia, muscle, or bone, is more probably neuralgic. Firm pressure often relieves the pain of neuralgia, but adds to the suffering in neuritis. In making this test it must be remembered that in neuralgia the skin itself may be hyperæsthetic when lightly touched, though firm pressure will relieve the pain.

In neuralgia there is no alteration in the shape of the part, as in local inflammation, and there is no fever. The trophic changes seen in neuritis are, of course, absent in the functional disease.

Neuralgia of the joints may simulate chronic inflammation. Neuralgia of the mammary gland in women of nervous temperament and disordered menstruation is liable to raise the suspicion of possible malignant disease. This is particularly the case if adenomatous or other benign growths are situated in the gland.

Treatment.—The neuralgias of hysterical and neurasthenic persons who are mentally and physically demoralized, the reminiscent neuralgias previously mentioned, and the neuralgias occurring in the degenerative period of life are difficult to cure. Their management belongs to the

domain of medicine. The cause should be removed, if possible, and the general nervous system given special attention. These cases should not be subjected to surgical operation until every cause of nervous strain and every depressing influence upon the mind have been removed. It is probable that many operations are unsuccessful because the surgeon has not realized that the disease is due to a worn-out nervous system.

Tumors, inflammatory exudates, foreign bodies, and cicatrices causing nerve-pressure, epiphysitis, bone disease, and other surgical conditions, and affections of the brain and spinal cord which give rise to pain, must be excluded before treatment is directed to the nerve in which pain is felt. It is often much easier to call a case "neuralgia" than to give the time and thought necessary to discover the real lesion which occasions the pain.

Anodynes and counter-irritants are much used in the local treatment. Belladonna ointment, menthol, cocaine, aconite, opium, and hyoscyamus are employed for their soothing effect, and may be combined with lanolin. Ointment of veratria (1 part to 25) or aconitia ointment (1 part to 100) is sometimes valuable. As counter-irritants, iodine, chloroform liniment, camphor and chloral, blisters, and the actual cautery may be found useful. A weak galvanic current, used for ten or fifteen minutes daily, with the positive pole near the seat of pain, may give relief. Massage is sometimes of service. A spray of methyl chloride and other local refrigerants may be used to numb the skin and relieve pain. Subsequent inflammation and gangrene may be produced if they are employed for too long a time.

Various remedies have been used for the constitutional treatment of neuralgia. Their efficacy depends upon the skill with which the surgeon has sought out the cause. They are often given credit for a cure which is largely due to the hygienic accessories which have been brought into play. Arsenic in increasing doses, iron, quinine, strychnia, zinc, and cod-liver oil are the most valuable remedies in debilitated cases. The bromides, asafœtida, valerian, and castoreum are antispasmodics often employed. Gelsemium pushed to its physiological effect, nitro-glycerin in large doses, and aconitia in doses of $\frac{1}{200}$ to $\frac{1}{150}$ of a grain, are drugs which also have a valuable place in the treatment of neuralgia. Phenacetin, antifebrin, and antipyrine may relieve the pain, but must be used with caution lest they induce habituation. The opiates are especially dangerous for the same reason. Salol and sodium salicylate are indicated in cases of supposed rheumatic etiology, while potassium iodide and mercury should be administered in cases of a possible syphilitic origin. Alkalies, lithium salts, colchicum, cannabis Indica, and cimicifuga should be used in appropriate cases.

The hypodermatic use of atropia and other remedies spoken of in the treatment of neuritis may at time be adopted with benefit. Ergot and phosphorus have been recommended in the treatment of neuralgia. When all these means fail surgical operation must be considered.

Various operative procedures have been adopted for the treatment of neuralgia when medical treatment has proved unavailing. Neurectasia, or nerve-stretching, neurotomy, and neurectomy are the operations usually employed for the relief of this painful condition. Acupuncture and galvano-puncture have been occasionally advocated. Compression of

the nerve against a bone by means of a screw-clamp, so as to crush its fibres, has been proposed for the purpose. Excision of a cortical centre in the brain or the spinal roots of the implicated nerves has been seriously proposed, and, I believe, performed in a few instances. Excision of the Gasserian ganglion and of the intracranial portions of the fifth nerve has been repeatedly performed, with great benefit, in trifacial neuralgia.

Neurotomy is seldom done at the present day, because the simple division of the nerve-fibres permits very early reunion of the cut ends. Neurectomy, in which a piece of the nerve is removed, is much more likely to give permanent relief, and is not a more serious operation than neurotomy. After neurectomy, which is done as far as possible behind the seat of pain, the distal end of the nerve may be bent backward or a piece of muscle or fascia interposed between the cut ends in order to prevent reunion of the divided nerve-trunk. A small piece of metal or celluloid might be similarly interposed and left within the tissues, but I know of no reported cases.

Nerve-stretching consists in exposing the nerve and making traction in a direction away from its cerebro-spinal connection. This operation is not likely to be as satisfactory as neurectomy, but has the advantage that the motor paralysis occurring from interference with the motor fibres in the nerve-trunk is not so great or lasting as after the operation of neurectomy.

Subcutaneous nerve-stretching is performed upon the sciatic nerve by flexing the thigh strongly upon the pelvis until the knee touches the the chest. During this procedure the knee is kept straight, so as to increase the tension upon the sciatic nerve. This operation is not very often done at the present time, because an aseptic incision is scarcely attended with danger, and permits the stretching to be done more efficiently.

A detailed account of the methods of performing these operations upon nerves will be given in a later section which discusses the Operations upon Nerves.

When neuralgia is due to a nerve being caught in an inflammatory exudate or in a cicatrix, excision of the compressing tissue and the nerve-fibres in it will usually be followed by permanent cure. If a nerve is entangled in callus which has resulted from a fracture, it is necessary to chisel away the osseous material and free the nerve. This operation is probably more often called for in fractures about the elbow than in other situations, because the ulnar nerve is liable to be entangled in callus situated behind the internal condyle of the humerus. After relieving the pressure upon an imprisoned nerve it is well to stretch the nerve before closing the wound.

Bulbous nerves found in stumps after amputation are often the seat of severe neuralgia, due to pressure exerted by the artificial limb. A true neuritis occasionally occurs in these bulbous tumors, which are really a form of neuroma. The possibility of the occurrence of such neuromatous enlargements after amputation furnishes a good reason for the surgeon to draw out the nerves at the time of amputation and cut them off as high as possible. An ascending neuritis may take place in nerves having bulbous ends in stumps. Hence it is often wise to do a

neurectomy early. This is probably better than being satisfied with stretching of the nerve either in the stump or at a point above.

NERVE-SPASM.

The spasmodic neurosis claiming attention here is that often called "convulsive tic," in which intermittent and involuntary motions of a choreic kind occur in groups of muscles physiologically associated. Surgical interference is at times demanded when the facial or the spinal accessory nerve is thus affected.

FACIAL SPASM.

Causes.—Facial spasm, histrionic spasm, or mimic tic causes irresistible twitchings of a few or many of the muscles of the face supplied by the seventh cranial, or facial, nerve. This condition is quite different from muscular spasm secondary to a paralyzing lesion involving the nerve.

The disease may be caused by tumors, softening, or other organic changes in the nerve-nucleus in the pons, in the corresponding centre in the cortex of the opposite side of the cerebrum, or in the nerve itself; or it may depend on unknown or nutritional changes and be called functional or idiopathic. Falls on the head, mental shock, anæmia, the neuropathic diathesis, and irritation of the trigeminal nerve, as well as other reflex agencies, appear to have been efficient causes. Gowers mentions an instance supposed to have been due to the habitual muscular movements resulting from snuff-taking. The majority of cases have no discoverable organic causation.

Symptoms.—The spasms are usually clonic, are unattended by pain or palsy, and are often limited to the muscles supplied by the upper branches of one facial nerve. The orbicular of the eyelids and the zygomatics are the muscles most frequently involved. Both nerves may be involved, however, and the muscles supplied by other nerves than the facial are occasionally thrown into spasms secondarily. Thus the muscles of the tongue, of the jaw, and of the neck and arm may be finally involved. The momentary contractions occur with great rapidity, and resemble the movements produced by application of the faradic current to the nerve. Exposure to bright light or cold, emotion, and similar excitants increase the twitchings. Tonic spasm is sometimes associated with the clonic spasms. The disease, which may have a remittent or an intermittent character, is difficult to relieve, but is unattended with danger to life unless it be a symptom of organic disease in the brain. The patient is of course much annoyed at his inability to avoid "making faces." This characteristic has given the names "mimic spasm" and "histrionic spasm" to the disease.

Treatment.—Causes of reflex irritation, such as diseased teeth, neuralgia, or errors of refraction, should be efficiently treated, the patient should be kept free from known emotional causes, and the general health should be brought up to the best standard. Both medicinal and surgical treatment have been conspicuously unsatisfactory. Cannabis Indica, arsenic, valerian, zinc, conium, gelsemium, hyoscyamus, chloral, cocaine, morphia, and the bromides have been used with occasional success. The danger of inducing morphia or other drug-addiction must not be forgot-

ten, since large doses and prolonged use are required in treating this disease. Galvanism is recommended rather highly by Dana. Blisters behind the ear have seemed serviceable. Stretching the nerve vigorously after exposing it near its exit from the sterno-mastoid foramen has been tried, but the improvement has not very often been lasting. The paralysis of motion so induced gradually disappears, but the spasmodic twitching usually returns as the muscles regain power through the regeneration of the nerve. Neurectomy will stop the spasm, but the permanent disfigurement of the face due to the paralysis so caused renders such procedure usually improper. Godlee[1] and Keen[2] have published collections of cases treated by nerve-stretching, but these show that the relief was often transient. It is worth trial in troublesome cases, as the scar made is insignificant.

Perhaps a neurotomy with immediate suture of the nerve might be justifiable, since union of the cut nerve with final restoration of motion without spasm might possibly be obtained.

The nerve is exposed for stretching by an incision in front of the auricle, as advocated by Hueter, or by the method of Baum, who makes the cut behind the auricle; the latter is preferable. The incision is an angular one, immediately behind the auricle, with the apex of the angle pointing backward over the tip of the mastoid process. The whole length of the incision should be about two and a half inches. The nerve will be found in the space between the sterno-cleido-mastoid muscle posteriorly and the parotid gland in front. In the bottom of this narrow space, at a depth of one inch or more, the nerve will be found lying upon the fascia covering the muscles on the front of the vertebral column. The operator will by this method reach the nerve about half an inch in front of its exit from the stylo-mastoid foramen. He should search for the nerve, which is rather small, at a point from a quarter to a half inch in front of the middle of the anterior margin of the mastoid process, keeping above the posterior belly of the digastric muscle. This muscle is not always seen in the wound. The styloid process of the temporal bone and the transverse processes of the vertebræ are valuable landmarks in carrying out the deeper dissections. Illumination of the narrow fossa in which the nerve lies with the head-mirror will aid greatly in the identification. Keen has used a needle-like electrode, which he passed over the structures until muscular responses showed that the nerve was touched. The wet-sponge electrode should at the same time be applied to the cheek. The current for this purpose must be weak, because a strong current may produce muscular contraction when the electrode is not in contact with the facial nerve, as the tissues in the wound are moist.[3]

SPINAL ACCESSORY SPASM—ONE FORM OF TORTICOLLIS.

Spasmodic torticollis is a neurosis giving rise to clonic or tonic spasms of the cervical muscles supplied by the spinal accessory and the upper cervical nerves. It must be distinguished from congenital wry-neck

[1] *Trans. Clinical Soc. London*, vol. xvi. [2] *Annals of Surgery*, July, 1886.
[3] A recent article on this subject, by Dr. W. C. Gray, entitled "Palmus," will be found in the *Amer. Journ. Med. Sc.*, May, 1895, p. 535.

and the forms occurring as symptoms of spinal caries, rheumatic myositis, tumors, and abscesses. In causation and symptoms the disease is analogous to facial tic, just described.

The sterno-mastoid is the muscle most commonly affected, though the trapezius, splenius, and other cervical muscles may be involved. When both the sterno-mastoid and splenius are involved, it is usually the splenius on one side and the sterno-mastoid on the other. If the sterno-mastoid and trapezius are associated in the spasm, they are usually on the same side. It must be recollected that contraction of a sterno-mastoid muscle rotates the face toward the opposite side, thrusts the chin a little forward, and brings the mastoid process of the same side and the back of the head nearer the clavicle. It is very much the movement caused by grasping a lock of hair near the mastoid process with the hand of the same side and making traction. The splenius, unlike the sterno-mastoid, rotates the head toward the side of the acting muscle. If both sides are affected, which is rare, the head is drawn backward. This is retrocollic spasm. The character of motion is modified by the nerves involved, but nearly always the two muscles supplied by the spinal accessory nerve—the sterno-mastoid and the trapezius—are involved.[1]

Excessive rotation without much retraction suggests that the sterno-mastoid of one side and the splenius of the opposite side of the neck are involved. The face will be turned away from the affected sterno-mastoid. Retraction of the head without much rotation points to the two trapezius muscles as being in fault. The muscles of the face and arm may become involved secondarily.

The rotatory jerking of the head is not generally accompanied by much pain, but the fatigue and annoyance from the incessant motion may be great. The spasms, which are usually clonic, may finally become tonic. Then the contracted muscles may only relax during sleep.

The **treatment** by full doses of nerve-sedatives is essentially the same as in facial spasm, and is nearly as unsatisfactory. Electricity, massage, continuous stretching of the neck by suspension with a jury-mast, or occasional suspension from a tripod by the weight of the body, neurectomy of the spinal accessory or upper cervical nerves, and partial or complete section of the muscles, are suggested. Cures occur, but failure to entirely or permanently relieve the patient is common. Mechanical support by a properly-adjusted apparatus sometimes gives comfort. Nerve-stretching and neurotomy of the spinal accessory are of little value; neurectomy has given better results. I have excised the spinal accessory and subsequently divided the splenius without benefit.

Stretching, division, or excision[2] of the spinal accessory nerve is accomplished by a three-inch incision along the anterior edge of the sterno-mastoid muscle, beginning at the point of the mastoid process. The region should be made prominent by having the shoulders of the patient raised on a pillow and the head thrown backward, with the face turned to the opposite side. After opening the cervical fascia, relaxing the tissues of the neck somewhat, and drawing the muscle outward and

[1] *Spasmodic Wry-neck and other Spasmodic Movements of the Head, Face, and Neck,* by Noble Smith, London, 1891.

[2] "Traitement du Torticollis spasmodique par résection du Nerf spinal," L. H. Pettit, *Revue d'Orthopédie,* Juillet, 1891, p. 279.

backward with a retractor, the surgeon will usually find the nerve crossing the transverse process of the atlas. It comes out from beneath the lower border of the digastric muscle, crosses this process, and enters the belly of the muscle. About half an inch of the nerve should be removed. It can be reached by incision posterior to the sterno-mastoid muscle, but the anterior route, although a little more difficult, ensures more certainly the removal of all the branches going to the sterno-mastoid as well as to the trapezius.[1]

Keen[2] has devised and performed an operation for dividing the posterior branches of the first, second, and third cervical nerves in spasmodic torticollis which has been unrelieved by excision of the spinal accessory. In this way he paralyzes the deep rotators of the head, which are often involved. A transverse incision is made, about half an inch below the level of the lobule of the ear, from the posterior median line outward for about three inches. The trapezius muscle is divided by a similar incision. The surgeon then dissects up the trapezius, and finds the great occipital nerve as it makes it exit from the complexus and enters the trapezius. The intramuscular aponeurosis within the complexus must be remembered as an anatomical fact, or the surgeon may be surprised at coming upon it. The nerve emerges from the complexus at a point between this aponeurosis and the middle line, usually about half an inch below the incision, and then enters the trapezius. The nerve is about the size of a stout piece of catgut. The next step is to divide the complexus transversely at the level of this great occipital nerve and to follow by careful dissection the nerve downward until its origin from the posterior division of the second cervical nerve is reached. This nerve should be divided and a piece removed behind the origin of the great occipital.

The inferior oblique muscle must be identified by following the suboccipital nerve, which passes immediately below the muscle toward the spine. The suboccipital triangle formed by the two oblique muscles and the greater posterior straight muscle of the head must be identified, as the suboccipital, or first cervical, nerve lies in this triangle close to the occiput. A portion of this should then be excised. About an inch lower down than the great occipital nerve and under the complexus is found the external branch of the posterior division of the third cervical nerve, which supplies the splenius muscle. This should be divided close to the bifurcation of the main nerve. Noble Smith,[3] Gardner,[4] Powers,[5] and perhaps others have operated in this manner, and have found the method very satisfactory. Gardner, who claims that he devised the operation before Keen, reports a case remaining well, though the report was made nearly five years after the operation.

Is has been suggested to remove the motor centre in the cerebral cortex in inveterate cases. This centre is approximately situated in the posterior portion of the first and second frontal convolution, just in front of the arm-centre.

[1] See Ballance, *St. Thomas's Hospital Reports*, vol. xiv. p. 95.
[2] *Annals of Surgery*, vol. xiii. 1891, p. 44.
[3] *Loc. cit.*
[4] *British Medical Journal*, Aug. 19, 1893; *Epitome*, p. 30.
[5] *New York Medical Journal*, 1892, lv. p. 253.

TUMORS OF NERVES.

Varieties.—Tumors connected with nerves are comparatively rare. Fibroma is the morbid growth most frequently found involving the peripheral nerves, but sarcoma, myxoma, glioma, neuroma, and carcinoma occur. Cysts so situated are probably the result of degenerative processes in previously solid tumors. Carcinoma when present is usually an infiltration from disease of neighboring structures. Syphilitic masses are seldom found except upon the intracranial portions of the cranial nerves.

Hyperplasia or hypertrophy of nerve-trunks is described, but is exceedingly uncommon. This increased bulk is not properly a tumor.

Neuromas, consisting of medullated or non-medullated nerve-fibres, are found connected with nerves. Nerve-cells have been, it is said, demonstrated in a few of such tumors, but I do not know that such ganglion-cells have been proved to exist in neuromas connected with peripheral nerves. The bulbous ends of nerves seen as a secondary condition after amputation are sometimes, at least, according to Bowlby, neuromas. This is an instance of tumor due to a traumatic cause. The painful subcutaneous tubercle described by the older writers is a small fibroma developed on a cutaneous branch of a sensory nerve. A tumor, often congenital, consisting of irregularly interwoven cords of nerve-fibres and connective tissue, has been named plexiform neuroma or plexiform neuro-fibroma. It has been found connected with cerebro-spinal nerves and with the solar plexus of the sympathetic nervous system. The nerve-fibres in neuromas on nerves are generally smaller than the proper fibres of the nerve, and are irregularly arranged.

Gross says that Moore met with an arterio-venous tumor of the popliteal nerve. Occasionally many tumors are found connected with one nerve, or many of the nerve-trunks are similarly involved by multiple growths. Prudden[1] has carefully studied such cases. Dr. T. S. K. Morton[2] has recently recorded an interesting case of sarcoma of the sciatic nerve and collected some similar cases.

Tumors connected with nerves are not properly designated as neuromas unless histological study shows that they consist largely of nervous tissue.

The tumor is usually within the sheath of the nerve. The fibres of the nerve may be separated and spread over the surface of the tumor, may run through it, or may pass along the side of the morbid growth, sustaining more or less compression.

Symptoms.—A superficial tumor will give rise to the physical signs of a growth along the known course of a nerve. It will be movable laterally, but not in the direction of the length of the nerve to which it is attached. The symptoms will depend on the physiological character of the nerve and the amount of pressure to which its fibres are subjected. A large tumor bound down by overlying fasciæ will give rise to more marked symptoms than under the opposite conditions.

No special symptoms may be presented, or paralysis, twitchings, pain, anæsthesia, paræsthesia, or reflex spasm may call attention to the prob-

[1] *American Journal of Medical Sciences*, vol. lxxx. p. 134.
[2] *Philada. Academy of Surgery*, Nov. 6, 1893.

able nerve-implication. Pain referred to the peripheral distribution of the nerve is not unusual. This is not to be expected in terminal tumors. Epileptiform seizures may be caused by painful tumors on nerve-trunks. An undiscovered tumor may be the cause of an unsuccessfully treated neuralgia.

Trophic changes in the nails and skin, such as are seen in neuritis, may arise; therefore glossy skin, painless whitlows, wasting muscles, and similar symptoms should lead to a search for a tumor connected with the nerve before idiopathic neuritis is assumed.

Treatment.—Excision is the only available treatment. The dissection should be made carefully in order that as few nerve-fibres as possible be injured. After the opening of the nerve-sheath the tumor can sometimes be enucleated without damage to the nerve-trunk. If it is necessary to sacrifice a portion of the nerve in the removal of the growth, suture of the ends of the divided nerve should be immediately performed. Relaxing the parts by flexing the joints and stretching the nerve will often allow apposition to be accomplished even when a considerable portion of tissue has been removed.

Nerve-grafting with a piece of nerve taken from one of the lower animals or from a recently-amputated human limb may be available. It is sometimes possible to bridge the chasm between the cut ends by dissecting a flap from the side of the nerve and turning it down, as is done in splicing shortened tendons after tenotomy. Where none of these measures are practicable, the cut ends should be held in position opposite each other by long stitches of catgut extending from one to the other. This procedure anchors the nerve-stumps in proper relation to each other. A tumor has been excised without the operator knowing that a nerve-trunk was involved until paralysis of the parts supplied showed itself. In such cases the wound should be opened if healing has taken place before the discovery, and nerve-suture performed.

Multiple tumors connected with nerves are scarcely suitable for excision. The pain can be relieved in some instances by excision of a portion of the nerve on the proximal side of the growths. Duhring and Maury[1] gave relief by excision of the brachial plexus in a case of this sort. An interesting specimen of multiple tumors of the median nerve has been deposited by Mears in the Mütter Museum of Philadelphia.

Injuries of Nerves.

Traumatic lesions of nerves are said to be more frequent in the upper than in the lower extremity. This is due partly to the more exposed situations in which the nerves of the upper extremity are found, and partly to the functional character of the upper extremity.

DISLOCATION.

Dislocation of the ulnar nerve from the groove in which it lies behind the epicondyle is a rare injury which may occur as the result of a blow received upon the nerve. Poncet[2] records an instance in which the condition was due to muscular effort exerted in throwing a snowball. Mac-

[1] *American Journal of Medical Sciences*, lxxiii. p. 413, and lxxxi. p. 435.
[2] *Semaine médicale*, 1e semestre, 1888, p. 39.

Cormac[1] and Lutz[2] have seen cases in which no history of traumatism was obtained. Blattmann's case[3] was caused by violent gymnastic exercise when the elbow was flexed. Holden[4] reports a case of luxation of both ulnar nerves from muscular strain exerted while the patient was holding the steering-wheel of a vessel in a storm. He suddenly felt something slip in both elbows, and felt a tingling pain in the distribution of the ulnar nerves. The nerves could be pushed in front of the condyles by slight pressure on the inner side of the elbow.

I have seen but one case of this dislocation, a patient of Dr. H. R. Wharton. The injury was due to direct violence, and the nerve could be seen slipping over the surface of the epicondyle when pressure was made and during certain voluntary movements.

From observations in the cadaver Annequin found[5] that when the nerve has been freed from its restraining fibrous bands dislocation is produced by flexing the elbow. He thinks that violent flexion of the elbow is sufficient to tear these bands and cause the dislocation.

The **diagnosis** is easily made by a movable cord being felt underneath the skin and by the tingling sensation experienced by the patient when pressure is made upon it.

If appropriate pads and enforced rest to the limb do not succeed in causing the torn tissues to unite so as to restrain the excursions of the nerve, it is proper to cut down upon the nerve and suture it in the proper anatomical position. This has been done successfully by G. Munro Smith,[6] MacCormac,[7] Croft,[8] and others. Andrae[9] in a case of several months' standing excised a portion of the nerve which was thickened, stretched the nerve, and then sutured. He obtained some improvement in the paralytic and atrophic symptoms.

Additional information on this injury may be sought for in the monographs of Schilling[10] and Raynonenq.[11]

COMPRESSION.

Slow compression of nerves differs from sudden and forcible compression, which is practically a contusion. Slow compression of the sciatic nerve occurs from prolonged sitting in postures which cause the weight of the body to come upon the sciatic trunk. Crutch-pressure on the nerves in the axilla causes a similar condition. This form of compression is also seen in the arm from lying upon it during deep sleep or intoxication, and in the leg from similar pressure of the external peroneal nerve against a chair or bed. The palsy so induced is sometimes erroneously attributed to exposure to cold.

The growth of tumors and the deposition of inflammatory exudates may give rise to slow compression. Exostoses upon the transverse pro-

[1] *Lancet*, 1891, i. p. 1040.
[2] *St. Louis Med. and Surg. Journ.*, 1879–80, vol. xxxviii. p. 550.
[3] See Andrae's monograph. [4] *British Medical Journal*, 1893, vol. i. p. 288.
[5] *Arch. de Méd. et Pharm. Mil.*, 1890, xv. p. 432.
[6] *British Med. Journ.*, 1893, vol. i. p. 298. [7] *Lancet*, 1891, i. p. 1040. [8] *Idem.*
[9] *Ueber Traumatische Luxation des Nervus Ulnaris am Elbogen*, Griefswald, 1889.
[10] "Ein Fall von Doppelseitiger Dislocation des N. Ulnaris," *Sitz-Protok d. ärztl. Lokalver. zu Nürnb.*, München, 1893, 28.
[11] *De la Luxation du Nerf cubital et en particulier Mécanisme et Traitement*, Lyon, 1890.

cess of the last cervical vertebra or upon the clavicle[1] may thus make pressure and cause paralysis of motion and sensation, and indeed trophic lesions, in the upper extremity. Compression of the brachial plexus has also been seen following fracture of the surgical neck of the humerus. Contraction of scar-tissue may make pressure upon nerves, and sometimes may even affect a nerve not really involved in the original wound. Callus thrown out after fracture of the humerus occasionally compresses the musculo-spiral or ulnar nerve. Improperly applied splints in cases of fracture may cause injurious compression of nerve-trunks. The nerve may be tensely stretched across a ridge of callus or be imbedded in it. Annequin speaks[2] of several forms of nerve-compression of bony causation—total inclusion of the whole nerve, with perhaps a bony canal; interposition of the nerve between the components of a false joint; peripheral enclosure in an osteo-fibrous groove, causing partial strangulation; compression by the end of a fragment after fracture, by an independent splinter, or by a loose piece of periosteum which has become ossified; and incarceration by scar-tissue in the region of the callous formation. Bruns found nerve-compression after fracture most common after humeral fractures, and the musculo-spiral the most frequent nerve so involved.[3] A palsy observed immediately after receipt of fracture is probably due to coincident contusion; secondary palsy is probably due to compression exerted in one of the ways just mentioned.

The lesion in slow compression is probably a mechanical disturbance of the elements of the nerve-fibres, giving rise to separation of the molecules of the white substance. An interruption of nerve-conduction is thus produced. Compression may cause palsy before the nerve is completely disorganized. The symptoms depend upon the intensity, duration, and particularly the rapidity, of the compression.

The **symptoms** are at first tingling and prickling sensations, with a feeling of numbness and warmth in the parts to which the nerve is distributed. These symptoms are followed by hyperæsthesia, muscular twitchings, anæsthesia, painful cramps, paralysis, and occasionally even gangrene. Cicatrix-compression may show its pressure by muscular atrophy and trophic changes, without pain or marked loss of sensation. A subjective sensation of cold and a feeling as if a heavy weight rested upon the limb are sometimes present. Inability to properly direct the movements of the affected muscles also exists.

The symptoms when due to a transitory cause gradually disappear and the patient remains well. Occasionally in hysterical subjects neuralgia may remain. The pressure produced by a too tightly applied or a too narrow Esmarch tourniquet induces a temporary paralysis which is probably due to this lesion.

The proper **treatment** is removal of the cause where it can be accomplished. Cicatrices and tumors may often be removed. Galvanism, friction, and massage are serviceable. It is possible that the symptoms may resist treatment because inflammatory adhesions have taken place around the nerve or chronic neuritis has occurred as a secondary lesion.

[1] *Gazette héb. de Méd. et de Chir.*, xxviii., 1891, p. 122.
[2] *Arch. de Méd et Pharm. Mil.*, xxii. 1893, p. 162.
[3] Francis W. Murray, *N. Y. Med. Journ.*, 1892, i. p. 708.

Hence in a certain number of cases it will be proper to cut down upon the nerve, free it by dissection from the inflammatory bands making pressure, and stretch it. This is the only proper treatment where the nerve is entangled in callus. I have seen distressing pain after union of a humeral fracture immediately relieved by an accidental refracture. The nerve entangled in the callus was probably the musculo-spiral. R. H. Sayre[1] has reported a case in which neuralgia was cured by loosening twisted muscles and fascia surrounding a fracture of the femur. No special nerve was discovered to be imprisoned. The nerve should be uncovered above and below the seat of compression, so as to avoid its accidental division while searching for it in the scar-tissue.

FIG. 504.

Foot-drop from epiphyseal fracture of lower end of femur and contusion of external peroneal nerve. The projection of the lower fragment backward can be seen at the outer part of the popliteal space. (Dr. Roberts's patient at Methodist Hospital.)

CONTUSION.

Contusion is a graver lesion than slow compression. The nerve-fibres are often broken, and may be subjected to the pressure of blood-clots and inflammatory exudates. The neuritis arising from such lesions may spread along the nerve-trunk. A common illustration of contused nerve is the injury of the circumflex nerve, due to falls on the shoulder, which gives rise to paralysis and atrophy of the deltoid and secondary adhesions in the shoulder-joint. Blows received upon the brachial plexus or upon the cervical nerves may cause nerve-contusions, followed by paralysis of the muscles to which these nerves are distributed. The paralysis of the seventh nerve shown in infants after delivery with forceps is probably a contusion.

The **symptoms** of contusion are similar to those of compression, but are more pronounced. If the muscles supplied by the nerve are not all paralyzed, it is evident that the nerve is not completely crushed, and the prognosis is more favorable. If rapid wasting of muscles occurs and the reaction of degeneration is present, the prognosis is more unfavorable and a longer time will be required for cure.

In nerve-contusions the paralysis of sensation is often not as great as that of motion. This is probably due to the fact that sensory fibres, when their anatomical structure is altered, conduct impressions more

[1] *New York Med. Journ.*, 1891, vol. ii. p. 206.

readily than similarly affected motor fibres. This is akin to the known fact that imperfectly regenerated sensory fibres conduct impressions better than imperfectly regenerated motor fibres convey motor impulses. The function of motor nerves probably requires a more perfect degree of conductivity to give the normal physiological result at the end-plates in the muscles.

The **treatment** consists in limiting or arresting inflammatory conditions, as described in discussing Neuritis. When absence of pain and the presence of other symptoms make it clear that the nerve has been absolutely destroyed, such antiphlogistic treatment is unavailing and unnecessary. Subsequently electricity, frictions, and counter-irritation should be employed. If there is a probability that inflammatory adhesions have occurred about the nerve, the trunk should be exposed and the nerve dissected loose from the compressing bands. Nerve-stretching should be done at the same time.

LACERATED AND INCISED WOUNDS.

These injuries are usually more important than contusions, because nerve-fibres are actually sundered, and if the nerve is completely divided the gap between the ends may be great. Howell and Huber[1] show that resumption of irritability is more rapid where the fibres have been crushed than where they have been divided and promptly sutured. The nerve-fibres may be completely divided without the nerve-sheath being torn asunder. Stewart has reported[2] such a case in which he performed secondary suturing of the ulnar nerve with perfect success. A partial division of the nerve, whether by laceration or incision, is less serious than a complete solution of continuity of the fibres of the nerve. The symptoms are less marked and repair is more readily accomplished.

Accidental ligation, as in cases where ligatures have been applied to nerves unintentionally during operations upon the blood-vessels, causes a lesion partaking of the character of compression, contusion, and laceration, depending upon the force with which the ligature has been tied. Punctured wounds of nerves have been looked upon as being particularly serious. It is probable that such wounds, if aseptic, are less serious than other aseptic traumatic lesions of nerves, because few fibres are wounded. It is probable that the bad symptoms occurring after many punctured wounds are due to the septic character which is likely to pertain to punctures of all structures, because of the depth of the wound and the manner in which deleterious secretions are retained.

The **symptoms** of lacerations and incisions vary with the completeness of division of the nerve-trunk. Comparison should always be made with the sound side. Complete division causes loss of sense of touch and of muscular power. There is often no more pain than that caused by dividing the skin. Numbness and tingling, however, attract the patient's attention, and cutaneous anæsthesia is usually present. Hyperæsthesia is rare, and possibly due to incomplete section of the nerve and a coincident neuritis. It sometimes occurs in the vicinity of trophic lesions and at a point where an anæsthetic region joins normal skin. Changes

[1] *Journal of Physiology*, Cambridge, 1893, vol. xiii. p. 335.
[2] *Trans. Med.-Chir. Soc. Edin.*, 1891–92, xi. p. 93.

in sensation should be measured by two points, like those of a pair of compasses, which can be brought together or separated. When the skin is thickened, as upon the hands of laborers, normal sensation is much less accurate than under other circumstances. The patient with injured nerve may feel contact of the points, but not be able to localize them accurately. It must be remembered that the distributions of cutaneous nerves overlap each other, and that the area of absolute anæsthesia may be quite small. Even when a comparatively large nerve has been completely divided, the nerve supplying the tissues underneath the skin at a given point may be different from the cutaneous nerves; hence deep pressure will perhaps give evidence of sensation when the skin itself is really anæsthetic. Increased sensitiveness and spontaneous pain may occur in the area of distribution where a nerve has suffered a partial lesion. Pain and tenderness of the nerve-trunk itself are sometimes experienced, and are due to increased sensibility of the nervi nervorum. Thermal sense may be defective. Friction should not be used as a method of determining anæsthesia, since the vibration caused by rubbing is perceived by neighboring nerves. It is possible that the adjacent nerves may act for the one injured by establishing a sort of collateral nerve-circulation. Alterations of skin, of the nails, and the other trophic lesions which have been described in the section on Neuritis occur.

The muscles show atrophy and the reaction of degeneration, and become shortened. Bowlby believes that this is not an active contraction of the paralyzed muscles, but that where the limbs assume positions which do not extend the muscles they become atrophied in their unopposed and shortened condition. Subacute inflammation of joints and burning pain are symptoms of nerve-injury. The tenderness, fibrous adhesions, and alterations in joints are usually chronic, and may be deemed an ordinary arthritis if the coincident muscular wasting, which may not be very great, escapes the surgeon's observation. It will be easily understood that many of these later symptoms are the result of the degeneration of the nerve which takes place after injury as after neuritis. In both instances it is often followed by regeneration of nerve-tissue. The ends of a divided nerve become bulbous, the proximal extremities having upon them larger bulbs than the peripheral.

Under some circumstances a wound of the nerve on one side of the body gives rise to paralysis on the opposite side. This reflex paralysis may occur immediately after injury or after the lapse of a considerable interval of time. It is often progressive. This paralysis has a tendency to show itself in the part corresponding with that supplied by the injured nerve, and may be due, in some cases at least, to an ascending neuritis with secondary implication of the cord. It seems to be true that such reflex palsies are more common where small nerves are injured, and after lacerations and punctures rather than incisions. The area supplied by the injured nerve is of course also the seat of defective sensation, motion, and nutrition.

Treatment.—When the symptoms indicate that complete division of the nerve has not occurred, treatment should be directed to limiting the activity of inflammation in the manner detailed in the discussion of Contusions. When a nerve has been divided, whether by laceration or incision, immediate suture should be undertaken. Indications of a solu-

tion of nerve-continuity should cause the surgeon to at once cut down upon the injured trunk for the purpose of uniting the separated ends. The cauda equina consists of nerve-roots, and should be treated by suture, as are nerves. Its capacity for regeneration resembles that of peripheral nerves; hence in injuries to the cauda the spinal canal should be opened and suture attempted.[1] There is abundant evidence that primary suture of a divided nerve is followed by much more rapid restoration of function than secondary suture done after muscular atrophy and other secondary changes have occurred.

Divided nerves are repaired by the deposition of what has sometimes been called "nerve-callus" between the ends. In this fibrous bond nerve-fibres are gradually developed, and the restoration of function thereby accomplished. Even the portion of nerve which has been cut off from its trophic centre, and which therefore has degenerated, becomes regenerated. If the gap between the separated ends is not too great, Nature will cause restoration of function by new fibres bridging the chasm, even when no attempt at suturing has been made. It will be readily perceived that the closer the approximation of the two ends, the more readily will continuity of the nerve-structure be effected. Some authorities believe that union by first intention may take place in nerve-fibres promptly and accurately approximated. Bowlby relates a case in which a median nerve sutured after division apparently conducted nervous impulses as well as ever at the end of three weeks.

Microscopical examination has not been obtainable to prove union by first intention in the human subject. It is possible that an early recovery of sensation and power is due to the establishment of a sort of collateral nervous circulation, without union by first intention occurring, and to neighboring muscles assuming the function of those whose innervation has been impaired.[2]

Catgut is probably the most satisfactory material for nerve-suturing, but if there is a good deal of tension, chromicized catgut or silk should be used. The stitches are passed directly through the sheath and the nerve, the ends of which should be neatly apposed without twisting or folding in the fibres. It is not desirable to pass the needles through the neurilemma only. Round or ordinary sewing needles do less damage than surgical needles. If the trunk is large, the sheath may be brought together by a special set of sutures after the nerve-ends have been sewn together. It is often well to insert a second suture in a plane at right angles to the first suture. The number of sutures need not be limited. The ragged ends of a lacerated nerve may with propriety be trimmed away. A very sharp knife will cause less bruising than scissors. The nerve should be strongly stretched if there is a considerable gap between the ends; thus approximation can often be obtained. When the loss of substance is great, strips of nerve may be cut from one side of each end, turned toward each other, and sutured so to bridge the intervening space. The distal end of a divided nerve may be stitched to a neighboring nerve if it is not possible to unite it with its own proximal end. The side of the nerve with which union is to be consummated may be

[1] *Annals of Surgery*, Oct., 1894, p. 457.
[2] In *Bull. de l'Acad. de Méd.*, xxix., 1893, p. 582, will be found an interesting physiological article on nerve-suturing by Brown-Séquard.

freshened, or the distal nerve-end may be inserted into a slit made in the former. This procedure leads to some irritation and damage of the nerve to which attachment is made, but this is often justifiable.

It seems as if a nerve-centre can be educated to perform a new kind

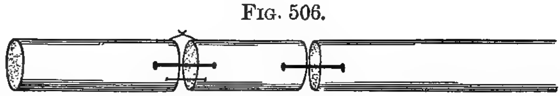
FIG. 505.

Neuroplasty (Willard).

of duty. The proximal portion of the spinal accessory nerve has been united to the distal part of a palsied recurrent laryngeal nerve in horses, with encouraging result.[1]

After removal of a tumor from a nerve-trunk or isolation of a nerve from a cicatrix, a gap may remain between the ends which cannot be so overcome by nerve-stretching as to permit suturing. A piece of nerve taken from a recently-amputated limb or from a living dog, rabbit, or kitten has been inserted in such gaps by Kaufmann, Tillmanns, Ward, Moullin, Robson, Atkinson, Landerer, and others. The animals should be young, as regenerative power is greater in them than in old animals. Robson used for the median nerve in one case a graft taken

FIG. 506.



Nerve-suture (Willard).

from the spinal cord of a rabbit, and had in six months muscular recovery and return of sensation. Atkinson[2] in excising the hip-joint cut out by accident one inch of the sciatic nerve; he immediately cleaned away the diseased tissue from the nerve and reinserted the piece as a graft. Sensation was almost completely restored. A return of muscular power is not recorded; hence motion had probably not been regained at the time of the report. Landerer[3] engrafted a piece of sciatic nerve from a rabbit into the radial nerve of a woman to bridge a gap three and a half centimetres long. Sensation returned in three weeks, and active motion was possible in ten weeks. The case was one of secondary suture.

Experimental work in the same line seems to show that these nerve-grafts act as a framework for new tissue, as do strands of catgut or a decalcified tube placed between the nerve-ends. It is possible that the grafts serve no other purpose, though it has been stated that they may produce embryonic nerve-fibres capable of assisting in reunion.[4] Sensation is, as would be expected, more quickly and more perfectly regained than motion. Nutritional recovery seems to be more effectual than motor recovery. The following table is worthy of study, though it does not pretend to contain all the cases reported :

[1] *Medical News*, March 25, 1895, p. 333.
[2] *British Med. Journ.*, 1890, vol. ii. 624.
[3] *Deutsche Zeitsch. für Chirurgie*, xxviii. 116.
[4] DeForest Willard, *International Medical Magazine*, April, 1894.

Cases of Nerve-grafting.

OPERATOR.	NERVE.	GRAFT.	Improvement in SENSATION.	Improvement in MOTION.	REFERENCES.
Moullin . .	Radial	Sciatic, dog .	Yes.	No.	*Lancet*, 1891, i. 1516.
Tillmanns .	Median and ulnar	Sciatic, rabbit.	Recovery.		*Berlin. klin. Wochenschr.*, June, 1885.
Kaufmann.	Musculo-spiral.	Sciatic, dog .	Unknown.		*Revue des Sciences médicales*, 1884, 305.
Robson .	Median . .	Spinal cord, rabbit . .	Yes.	Yes.	*British Med. Journ.*, 1890, ii. 624.
Ward .	Median	Median, human	Yes.	Yes.	*Idem.*
Atkinson .	Ulnar	Sciatic, rabbit.	Yes.	Not stated.	*Idem.*
Robson .	Median . .	Posterior tibial, human .	Satisfactory cure.		*Idem.*
Heath . .	Ulnar . . .	Posterior tibial, human .	Unsatisfactory.		*Lancet*, 1893, i. 1194.
Gersung . .	Median . . .	Sciatic, rabbit.	Yes.	Not stated.	*British Med. Journ.*, 1888, i. 1070.
Atkinson .	Sciatic	Sciatic, human . . . (The piece that was accidentally excised) . .	Yes.	Not stated.	*Idem.*, 1890, ii. 624.
Harrison .	Median	Kitten . . .	Yes.	Yes.	*Trans. Clinical Soc. London*, xxv. 166.
Banks . .	Ulnar . .	Sciatic, dog .	Yes.	Not stated.	*Idem.*
Landerer .	Radial .	Sciatic, rabbit.	Yes.	Yes.	*Deutsche Zeitschr. für Chirurgie*, xxviii. 116.

Threads of catgut may be carried across the breach by making long stitches from one end to the other. When none of these devices are employed, the ends which cannot be approximated should be stitched opposite to each other by a suture holding each to the adjacent tissues.

The **prognosis** after primary suture is good, though motion and sensation may not return for months or even several years. Motion returns more slowly than sensation. Return of function may be so tardy as to lead to the erroneous belief that the sutures have given way. Two or three years may be required to obtain restoration, which may then be complete. The muscles regain power and bulk after nerve-suture. Recovery seems to be quicker in young patients. Re-education of the brain is necessary after suture, for many fibres have not been united to their own proximal stumps. Time is required to correct the abnormal connections. Howell and Huber[1] found that a nerve stitched to another nerve did not seem to recover functional activity as quickly as when united to its own stump.

If suppuration and gangrene take place and interfere with union, secondary suture must be done.

The **treatment** after suture consists in keeping the limb at rest in splints for a few weeks, so as to avoid strain on the line of suture. Subsequently faradism is indicated to keep up the muscular condition, so that when the nerve is regenerated the muscles will be ready to respond to the nerve-stimulation. If no response is given to the faradic current, galvanism is to be used until improvement in this respect is shown. Faradism is then to be substituted. Tenotomy to overcome deformity, massage, and passive motion are valuable adjuncts. Stimulation of the surface with the electric brush, after drying the skin with flour, and hot and cold douches, should not be neglected. For muscular spasm deep hypodermic injections of atropia are advised.

[1] *Journal of Physiology*, Cambridge, 1893, xiii. 335. See also M. J. V. Laborde's article in *Bull. de l'Acad. de Méd.*, 1893, p. 313.

When primary suture has not been done, secondary suture is proper. If the wound is partially healed, its edges are to be separated and the ends of the wounded nerve isolated from surrounding structures. In cases where cicatrization is already complete the surgeon should lay open the parts by free incision and make a careful search for the nerve-ends. The operation is more readily performed if artificial anæmia by the Esmarch apparatus has been obtained. Cicatrization may have displaced the nerve-ends and may require quite a long incision to be made. The upper end is usually more easily discovered. After the ends have been found they should be freshened by trimming away their extremities with a very sharp knife. It is best to make the section of the upper end at the upper part of the bulbous extremity. Bulbous neuromas will be found to exist on both ends if much time has elapsed since the date of the original injury. Young nerve-fibres exist in the bulb, and the fibrous tissue there present gives a good hold for the sutures. The lower nerve-end will be found degenerated, but it is useless to cut away successive portions of nerve-tissue with the expectation of reaching more healthy structure. The end should be cut away only so far as it is involved in the scar-tissue. In the manipulations about the nerve-ends it is well to avoid pinching the nerve-fibres. The forceps, therefore, should, so far as possible, grasp only the sheath. Apposition of the ends where the gap is not very great may be gained by stretching the nerves. Such stretching is more readily done after the constriction of the Esmarch bandage has been removed. Gardner,[1] when attempting secondary suture of an injured ulnar nerve, found it impossible to bring the ends of the nerve together. He therefore changed the course of the nerve by putting it in front of the elbow-joint and suturing the ends to each other. Cure followed, with return of sensation and motion. The nerve-fibres may require, for bringing them into apposition, nerve-grafting or neuroplasty

Fig. 507.

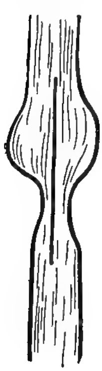


Fig. 508.

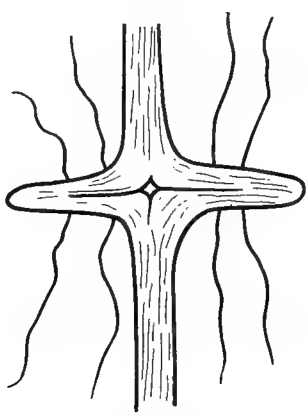
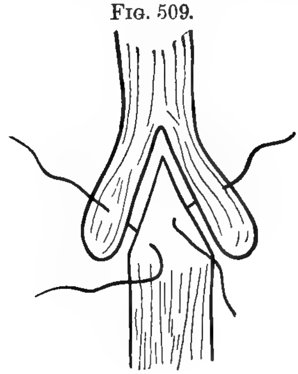


Fig. 509.



in some form. The above diagrams (taken from Willard) give some of the devices possible, especially when nerve-stretching is added to lengthen the trunk.

Return of sensation and motion will probably be slower in secondary

[1] *Lancet*, 1891, ii. 808.

suture than after the primary operation. Sensation is apt to return earlier than motion. Sometimes it is lost again, though it subsequently returns. Many months may elapse before repair of the nerve and restoration of function in the atrophied muscles occur.

The final **prognosis** is good after both primary and secondary suture. Secondary suture done several years after the original injury is, according to Bowlby, almost as likely to result in return of function as secondary suture done at an earlier date. If changes in the spinal cord itself have occurred as a consecutive lesion after nerve-injuries, success is not to be expected after suture. Howell and Huber report[1] in 84 cases of primary suture 42 per cent. successful, 40 per cent. improved, and 18 per cent. without benefit. Bowlby, in a table of 81 cases, records 32 successes, 12 doubtful successes, 22 partial successes, 14 failures, and 1 case of which the result was not known. He believes that many of the cases only partially successful at the time of report probably showed further restoration of function at a later period. The same author's statistics of secondary nerve-suture show, in a total of 73 cases, 32 successes, 26 partial successes, and 15 failures. Howell and Huber, in 80 recorded cases of secondary suture, find that 38 per cent. were successful, 50 per cent. improved, and 12 per cent. failures. It is probable that some of the partially successful cases in these tables subsequently recovered more perfectly. Rhein tabulated for Willard[2] 123 cases of primary nerve-suture and 130 cases of secondary suture. Even of the secondary cases 80 per cent. were improved by the operation. If no improvement takes place from secondary suture after the lapse of two or three years, it seems justifiable to repeat the operation. It certainly should be repeated if suppuration or gangrene interfered with the result in the first instance.

Nerve-injuries occurring in connection with dislocation and fracture must be treated on the general principles already laid down. Reduction of the displaced bone or fragment will often relieve injurious pressure and the compressed or contused nerve will eventually recover. Under other circumstances it may become necessary to do osteotomy, excision of bone, or nerve-suture to ensure integrity of nervous conductility. The surgeon must not forget that injured nerves recover function slowly. Operations of this kind need not be too hastily undertaken. Ankylosed joints near the injured nerve should be made movable by passive motion when the condition of the bones permits.

Injuries of Special Nerves.

The determination of the nerve injured or diseased, and therefore requiring surgical attention, is often easy when an open wound exists. When the nerve-lesion is subcutaneous the sensory and motor symptoms may be the only guide. Then a careful anatomical and physiological investigation is demanded.

CRANIAL NERVES.

Injuries of the nerves supplying the eye scarcely demand considera-

[1] *Journal of Physiology*, xiv. 1893. An elaborate article on the subject by J. H. Ehrman will be found in *Cong. franç. de Chirurgie*, vi., 1892, p. 428.
[2] *Medical News*, Oct. 6, 1894, p. 375.

tion here; their study belongs especially to the ophthalmologist. The trigeminal nerve frequently demands operative attack for the relief of violent epileptiform neuralgia. The distribution of its three branches to the forehead, cheek, and chin, and their exits from the supraorbital, infraorbital, and mental foramina, must be remembered.

The facial nerve may be encroached upon by tumors, and may be wounded in fracture of the petrous portion of the temporal bone and in operations, as well as gunshot and other wounds, in the vicinity of the lobe of the ear. Necrosis or caries secondary to middle-ear disease may interfere with its function. The symptoms due to its destruction or division will be motor paralysis of the muscles of expression on the corresponding side of the face. The eyelids cannot be completely closed, though the eyeball is movable; the mouth on that side is motionless and the saliva escapes from its corner, and that half of the face is stolid and unemotional in expression. Food accumulates between the alveolar processes and the inner side of the cheek on the paralyzed side, because the buccinator muscle has lost power. If the injury is behind the chorda tympani branch, the sense of taste will be imperfect.

The pneumogastric nerve may be tied or divided in ligation of the carotid artery and in extirpation of tumors. In thyroidectomy its recurrent laryngeal branch, lying in the groove between the trachea and œsophagus, is liable to be damaged. The voice becomes lost or hoarse if the nerve or this branch is injured. Dyspnœa may also be present. Unless the nerves of both sides are involved in the injury, the symptoms are not likely to be urgent. If both nerves are injured, instant tracheotomy should be done to prevent asphyxia. While I was ligating the common carotid artery on one occasion the etherized patient showed marked disturbance of respiration, which was supposed to be due to the anæsthetic. Before I tied the ligature which had just been carried around the vessel I found that the pneumogastric nerve, as well as the artery, had been encircled by the aneurysm needle. No other symptom pointing to interference with the pneumogastric was noticed. The respiratory phenomenon may in truth have had no connection with the slight pressure made on the nerve as it was raised a little from its bed. A case of removal of a sarcoma from the pneumogastric nerve has been recorded[1] by Ramoneda.

Spinal accessory injuries cause palsy and atrophy of the sterno-mastoid and trapezius. Traumatism of the hypoglossal nerve would be indicated by loss of power on one side of the tongue, which would be protruded toward the side of the injured nerve, and by some imperfection in swallowing and speaking.

CERVICAL NERVES.

Section of the phrenic nerve would, it is believed, cause congestion of the lung on the same side as a result of the palsy of the diaphragm. Mackenzie reports[2] a case of rupture of the right phrenic nerve followed by instant death, and Clark has recorded[3] a case of supposed injury to the phrenic nerves and diaphragm in which recovery took place. Com-

[1] *Revista Clin. de l'Hosp. Madrid*, 1891, iii. 241.
[2] *Med.-legal Experiences in Calcutta*, 12°, Edinburgh, 1891, p. 99.
[3] *Trans. New York Med. Ass'n*, 1891, p. 285.

pression of the phrenic nerve has been suggested as a therapeutic measure.[1] The sympathetic nerve has suffered injury in the cervical region. A few cases have been collected and summarized by Bowlby. In them the eyelids on the injured side were partially closed, the palpebral fissure was narrowed, the eyeball sunken in the orbit, the conjunctiva more vascular than usual, the pupil contracted, and the nasal secretion, the saliva, and the sweat diminished.

NERVES OF THE UPPER EXTREMITY.

The ulnar nerve is with comparative frequency injured by wounds in the neighborhood of the wrist. In the upper part of the forearm it is protected to a certain extent by the overlying muscles. It is, however, easily injured behind the internal condyle and in the upper arm. The muscles paralyzed by section of the ulnar nerve are the ulnar flexor of the wrist, the ulnar half of the deep flexor of the fingers, the muscles of the hypothenar group, two lumbrical muscles, all the interosseous muscles, the adductor of the thumb, and half of the short flexor of the thumb. It will be seen that the muscles paralyzed by ulnar injury are those most important in performing the delicate movements of the fingers. As a result of the paralysis and consecutive muscular atrophy the hand becomes a shrunken and useless claw. The last two phalanges of the fingers maintain a semi-flexed position, while the first phalanges are markedly extended. When the patient attempts to grasp an object in the palm there is a peculiar bending of the fingers into the palm by over-action of the deep and superficial flexors of the fingers acting upon the last two phalanges. Flexion of the first phalanges is impossible, and therefore he cannot bring the tips of the fingers against the elevations at the base of the thumb and little finger.

The area of anæsthesia will be found to occupy the ulnar side of the back and palm of the hand, the whole surface of the little finger, and the ulnar half of the ring finger near its tip. The extent of anæsthesia is not exactly the same in all patients.

The median nerve is most apt to be divided in wounds of the palmar surface of the forearm near the wrist. The extent of paralysis will vary as section of the nerve is made in the arm or forearm. If the traumatism is located high in the arm, paralysis will be observed in all the pronators and flexors arising from the condyles of the humerus and from the radius and ulna, except the ulnar flexor of the wrist and the ulnar half of the deep flexor of the fingers. The adductor of the thumb and one-half of the short flexor of the thumb will escape, but the other muscles of the ball of the thumb will have lost power, as will the two other lumbricals. Flexion of the wrist and pronation and supination of the hand will be defective, but will not be entirely lost, because the muscles supplied by the ulnar nerve are unimpaired. The most characteristic symptom is due to the loss of power in the flexor of the metacarpal bone of the thumb. This makes it impossible for the patient to oppose the tip of the thumb to the end of the little finger. The palsy of other muscles makes flexion of its terminal phalanx impossible. Its proximal phalanx, however, can be flexed, though not forcibly, because the necessary muscle is supplied in part by the ulnar nerve. The thumb

[1] *New York Med. Journ.*, March 17, 1894, p. 351.

is therefore extended, adducted, and drawn close to the index, as in the hand of the ape. Flexion of the fingers is impaired because the muscles to the second and third phalanges of the index and middle fingers are palsied. The interosseous are functionally active, however; hence the first phalanx of these two fingers can be flexed. The first and second phalanges of the ring and little fingers show loss of power, because the superficial flexor of the fingers is paralyzed. Some power remains to them, because half of the deep flexor is supplied by the intact ulnar nerve. In cases of some duration atrophy of the forearm occurs, and is shown especially on the radial side; the wrist is bent toward the ulnar side and is somewhat extended; the ball of the thumb is atrophied, and the head of its metacarpal bone very conspicuous.

Loss of sensation is evident on the palmar surfaces of the thumb, index, middle finger, and the radial half of the ring finger, and on the radial half of the palm, except a small portion of the ball of the thumb, which is supplied by the external cutaneous nerve. The backs of the index, middle, and half the ring finger show loss of sensation. There exists also an anæsthetic area on the dorsum of the last phalanx of the thumb. The authors which give the radial nerve control of the sensation of these dorsal regions are evidently inaccurate. The areas of anæsthesia vary somewhat in different individuals, and supplementary sensation furnished by nerve-anastomosis may here, as in other nerve-injuries, change the lines between anæsthetic and normal areas.

When the nerve is injured near the wrist fewer muscles are paralyzed, but the characteristic behavior of the thumb due to the loss of power in the opposing muscle—the flexor of the metacarpal bone—remains.

Section of the radial nerve is of minor importance, as it only causes anæsthesia on the back of the hand over the first and second metacarpal bones and on the dorsum of the thumb. It is liable to be injured where it passes around the base of the thumb from the palmar to the dorsal surface of the wrist.

The musculo-spiral nerve suffers injury at times in fracture of the humerus, because its winding course around the shaft of that bone makes it vulnerable. Deep wounds from the surface and abscesses may interfere with its integrity. The muscles paralyzed are the extensors of the forearm, wrist, fingers and thumb, and the supinators. Extension of the elbow, wrist, and basal phalanges of the fingers is impossible. The second and third phalanges become flexed, but can be extended by the lumbrical and interosseous muscles if the first phalanges have previously been flexed. The biceps, acting as a supinator as well as flexor, gives the patient some power of supination, though the long and short supinators are paralyzed. The wrist-drop due to this injury is characteristic. This nerve is the one so liable to be compressed when a drunkard or heavy sleeper lies on his arm, and the muscles supplied by it often lose power in lead-poisoning. These two conditions therefore give symptoms similar to division or laceration of the musculo-spiral nerve.

Sensory paralysis after musculo-spiral injury will be found on the outside of the arm from the deltoid insertion to the elbow, extending about one-fourth around the arm; on the radial side of the dorsum of the forearm at its upper and middle thirds, and over a small space in

the lower third on a line with the first and second metacarpal bones; on the dorsum of the thumb, the dorsum of the metacarpal region of the thumb, index, and middle fingers, and over part of the phalanges of the last two digits. The height of the lesion modifies the extent of the sensory as well as the motor symptoms.

Injuries involving the brachial plexus or two or more of the nerves already discussed will give the combination of symptoms to be expected from their respective distributions.

NERVES OF THE LOWER EXTREMITY.

The peroneal or external popliteal nerve may be accidentally divided during tenotomy of the external hamstring tendons. Such an injury destroys the power of the muscles on the front of the leg which flex or raise the foot; hence a paralytic foot-drop occurs. The patient drags his foot, as is shown by the rapid wearing out of the sole of the shoe under the great toe.

Injury of the great sciatic nerve causes paralysis of all muscles below the knee, while the thigh-muscles are not involved. The gait is peculiar, because the muscles controlling the hip are used to throw the limb forward at each step. The sensory palsy is less marked, and is evident on the foot and outer part of the leg.

Lesion of the anterior crural nerve causes loss of function of the anterior thigh-muscles and sensory palsy of the inner side of the thigh and leg. Flexion of the thigh at the hip is impaired, and walking or running is performed only with great care, and may be impossible.

Nerve-stretching, or Neurectasy.

Since Nussbaum in 1872 stretched the brachial plexus successfully for painful spasm of the arm and hand, nerve-stretching has claimed a good deal of attention. It has been found useless in many conditions, but its occasional value must be recognized. In neuralgia and muscular spasm it is sometimes undertaken before the adoption of the slightly more serious operations, neurotomy and neurectomy. Neurectomy has now nearly superseded both nerve-stretching and neurotomy in these conditions, because of its greater efficiency. There is no objection to performing nerve-stretching at first, for it can be followed by the other operations if it proves to be unavailing. When the operation was introduced it was used in ataxia, epilepsy, tetanus, and many other nervous diseases, but was of so little service that it is seldom employed at the present time except for the relief of neuralgias and spasmodic affections, such as mimic spasm of the face and spasmodic torticollis. Dr. Kenneth McLeod advocates[1] it strongly in anæsthetic leprosy to relieve the nerve-fibres from the destructive pressure present, and advises in this and other forms of neuritis that longitudinal division of the sheath of the nerve be made before the stretching is performed.

Neurectasy is done by exposing the nerve through an incision, as in ligating arteries. The nerve is then separated from the adjacent muscles and fasciæ, and stretched by means of the fingers or a hook passed beneath it. When the Esmarch tourniquet has been used to keep the parts blood-

[1] *British Medical Journal,* 1894, i. 352.

less during the incision, it must be removed before elongation of the nerve is attempted. If this is not done, the tension applied to the nerve is arrested at the seat of constriction caused by the bandage. The sheath of the nerve is not opened, and the operator desists when he feels that there is danger of causing complete rupture of the nerve-trunk. The giving way of some of the bundles of nerve-fibres is often appreciable to the surgeon during the stretching process. McLeod, as already mentioned, believes that the efficacy of neurectasy is enhanced in sclerosed conditions following neuritis by a preliminary longitudinal incision of the nerve-sheath.

What has been called subcutaneous nerve-stretching is sometimes applied to the great sciatic nerve. The operation is done, without making an incision, by flexing the hip of the etherized patient, while the knee is kept extended, until the point of the knee is brought almost or quite into contact with the front of the chest. The sciatic nerve is stretched by this manipulation, but great strain is also brought upon the biceps, semi-membranous, and semi-tendinous muscles on the back of the thigh, which extend from the tuberosity of the ischium to the tibia and fibula. Benefit has been derived from this inaccurate operation, but, on the other hand, fatal issue has also occurred. The open method is a more surgical and exact procedure.

Elaborate experiments have been made to determine the number of pounds that can be put upon the various nerves without causing complete rupture. The statistics based upon the tensile strength of nerves in the cadaver are of little practical value. The surgeon should stop when he has produced marked elongation of the nerve-trunk and has felt the giving way of a few of the component fibres. It is probable that a force of from thirty to forty pounds is as much as should be applied to even the largest nerves. When operating upon the facial nerve the operator may usually apply enough force to almost lift the head from the table. In stretching the sciatic nerve the whole limb, and even the hips, may with safety be lifted by the fingers hooked under the nerve. These examples give a crude idea of the amount of force usually applied in performing the operation.

The traction is exerted upon the peripheral as well as the proximal portion of the nerve. Most of the elongation occurs in the proximal portion, and there is no doubt that the dura mater and spinal cord may sustain traumatic lesion during the operation, though the force is applied at a great distance from the spinal cord. If the traction is made away from the spinal cord, the function of the sensory fibres is, it is believed, more impaired than that of the motor fibres. In the treatment of neuralgia centrifugal traction is therefore indicated. Traction toward the spinal cord seems to interfere especially with the function of the motor fibres. It is therefore indicated in operations for the cure of muscular spasm.

The pathological changes caused by the operation are loosening of the nerve-sheath from its attachment to the nerve, and narrowing of the sheath, so that it makes pressure upon the nerve-fibres. The blood-vessels are lacerated and ecchymoses produced, and some of the nerve-fibres are torn and degenerative processes set up. Cell-proliferation occurs in the neurilemma. Regeneration in time succeeds the degenera-

tion of the nerve, and occurs more rapidly than when the nerve has been subjected to accidental or intentional section. The sensory, motor, and trophic symptoms resemble those produced by an accidental laceration of like severity. The operation also causes inflammatory and atrophic changes in the cord. The benefit derived from neurectasy is not understood, but is probably due to separation of adhesions outside or within the sheath, to some unintelligible alteration in nutrition, or to the fact that the conducting fibres are actually severed, not only at the point of operation, but in distant branches. The operation may perhaps give better opportunity for the growth of new nerve-fibres. Experience seems to show that the operation has two apparently contrary effects: a hyperexcitation if the stretching is moderate; a functional abolition if it is complete.

Nerve-stretching done with proper asepsis is not a dangerous operation. Reflex palsy of the other side may occur, as in accidental traumatism of nerves. In cases which become septic pus may burrow within the nerve-sheath, and thus travel beyond the limits of the original wound. Death may take place from spinal meningitis or myelitis, due to injury to the cord caused by the efforts at stretching. Bowlby has reported thirteen cases of this sort. These complications, however, are rare, and need not deter one from carefully performed operations.

Nerve-section, or Neurotomy; Nerve-excision, or Neurectomy.

Intentional division of a nerve and the cutting out of a portion of it are operative procedures that only differ in that neurectomy leaves the nerve with a wider gap between the two ends. Neurectomy is the better operation, because the neuralgia or muscular spasm for which operation is undertaken is not so liable to recur by rapid regeneration of the nerve if the gap between the two ends is the wider one.

Neurotomy may be done subcutaneously by a tenotome passed through the skin, but the method is inaccurate. The method of exposing a nerve for either operation is identical with that used in nerve-stretching. When it has been found, it is lifted from its bed and divided with knife or scissors if the operation is to be neurotomy. In neurectomy the nerve is dragged upon so as to stretch both its central and peripheral portions, and a piece cut out with the knife or scissors. When the point at which division is desirable is inaccessible because the nerve lies in a bony canal, the surgeon may pull upon the nerve until it is torn off at a distant point.

If several nerve-trunks lie close together, as in the axilla, a weak faradic current may be used to identify, by muscular contractions, the particular nerve upon which operation is to be performed. The current should not be a strong one, because the moisture in the wound may conduct it to a distance and stimulate other nerves adjacent to the one desired.

As interruption of nerve-conductivity is the end to be desired in these operations, regeneration is to be deprecated. In neurectomy a piece of nerve several inches in length and its collateral branches are often cut out. Return of symptoms is usually evidence that union of the ends and regeneration of nerve-tissue have occurred. It is possible

that the recurrent pain or spasm may be due to supplementary or collateral innervation. Attempts have been made to prevent union after neurectomy by turning back the extremities of the nerve or introducing portions of muscle, fascia, or bone between them. Pieces of metal or celluloid have even been inserted for this purpose.

Nerve-suture, or Neurorraphy; Nerve-grafting.

Nerve-suture and nerve-grafting have been considered in discussing the treatment of Wounds of Nerves.

Operations on Special Nerves and Ganglia.

NERVES AND GANGLIA OF THE HEAD AND NECK.

The Trigeminal Nerve; Gasserian Ganglion.

The trigeminal nerve and its branches are often subjected to neurectomy, combined with nerve-stretching, for the relief of the excruciating pain of epileptiform neuralgia. The great and immediate relief afforded by the operation is often not permanent, but several months or years of comfort fully justify the slight operative risk. When the pain returns the operation should be repeated, preferably at a point nearer the brain. Sometimes the excision of the scar-tissue at the seat of the former operation gives relief again, even when no nerve-fibres can be identified in the mass removed. The operator should at the same time endeavor to stretch the nerve above the seat of operation by pulling on the tissues supposed to be connected with the nerve-stump. Thiersch has recommended neurotomy followed by torsion of the proximal end for the relief of the pain. Wyeth has reported[1] two cases successfully treated in this manner. The nerve was given ten to twenty rotations, which were made slowly while the nerve was slack and therefore not readily torn.

It is usual to be satisfied in the first operation with simply excising a portion of the painful supraorbital, infraorbital, or inferior dental nerve at or a short distance behind its respective foramen of exit upon the face. After months of comfort pain may recur. Then excision is performed at the foramen of exit at the base of the skull. Later, the main divisions of the nerve, the Gasserian ganglion, or the nerve-roots may be attacked by boldly entering the cranial cavity.[2]

Excision of the supraorbital branch is accomplished by a horizontal cut under the edge of the upper margin of the orbit. The point of junction of the nasal and middle thirds of the supraorbital ridge marks the foramen of exit. Sometimes the nerve lies in a notch instead of a foramen. When the nerve has been found at the bottom of the incision the fat of the eye-socket is pushed downward. The nerve is then lifted on a hook, followed along the roof of the orbit, and cut off as far back as possible after a strong pull being given it to stretch the cerebral portion. The terminal filaments entering the tissues of the forehead are next torn out by pulling on the free end.

[1] *Denver Medical Times*, 1892–93, xii. 10.

[2] The literature of this subject is very extensive. Important papers will be found in the *British Medical Journal*, 1891, vol. ii. pp. 1139, 1191, 1249.

The superior maxillary division or branch of the trigeminal nerve leaves its canal in the floor of the orbit by the infraorbital foramen. This foramen is situated about a quarter of an inch below the lower margin of the orbit, on a line drawn from the supraorbital foramen, mentioned just above, to the groove between the two lower bicuspid teeth of the same side. The concavity in the surface of the upper maxilla and the fact that the elevator muscle of the lower lip covers the foramen cause the nerve to seem rather deep when its excision is attempted.

Neurectomy of the superior maxillary nerve is performed by attacking it through the floor of the orbit, the roof of the antrum, or the pterygo-maxillary fissure. Many operations, utilizing one or other of these routes, have been devised,[1] but only a few that seem most desirable will be described here.

The first method is easy of execution. A long curved incision parallel to the lower margin of the orbit is made over the infraorbital foramen, the foramen and nerve identified, and a portion of the orbital edge just above the foramen cut out with a chisel. It is well to pass a ligature around the nerve to serve as a means of traction, or better, as was long ago suggested, seize the nerve with a pair of torsion forceps placed at right angles to the nerve, and then twist the nerve around the forceps. In this way the nerve can be extracted, and remains untorn for any required length. The tissues in the orbit are pushed upward with a flat spatula, and the thin bony partition between the orbital cavity and the nerve-canal broken through with any small steel instrument. The surgeon may, if he prefer, strip up the periosteum before he breaks through the bony septum over the nerve. The uncovered nerve is lifted from its bed with a small hook, is stretched by traction on the ligature in front, and is then cut off with curved scissors as far back as possible. If the periosteum has been stripped up, it is possible to trace the nerve back to the foramen rotundum and remove the spheno-palatine ganglion with the nerve. The terminal filaments of the nerve should be torn from the muscular and cutaneous tissues, which they supply with sensation, by a steady pull on the already divided nerve.

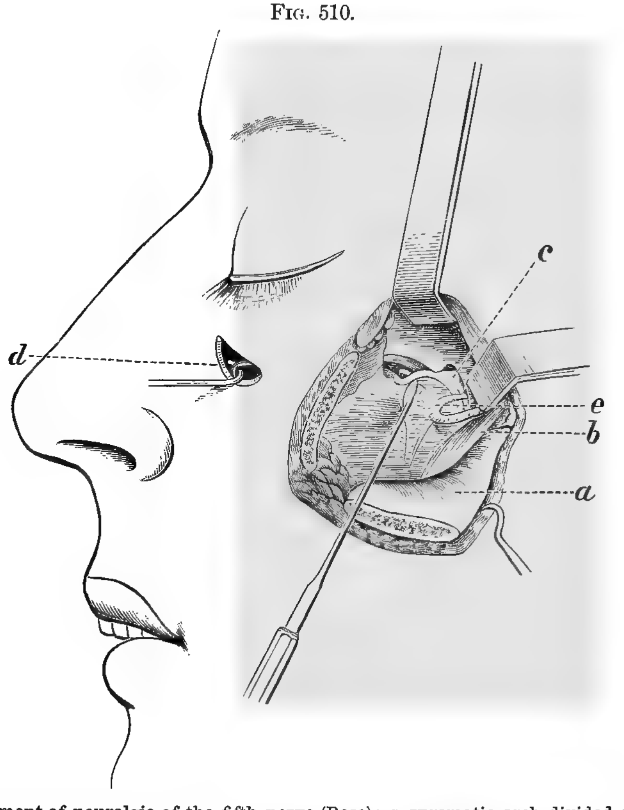
Excision of this nerve and the spheno-palatine ganglion (Meckel's) is performed by exposing the front of the upper jaw-bone by means of a horizontal incision, slightly concave upward, under the eye. From this an incision, not always necessary, may be carried downward toward the mouth, but not opening its cavity. The scarring will be less conspicuous if the second cut follows the naso-labial groove in the skin. The infraorbital nerve is found and a ligature tied to it. An opening nearly an inch in diameter, including the infraorbital foramen, is then made through the anterior wall of the jaw, entering the antrum. A similar opening is cut by trephine or gouge through the posterior wall of the antrum. This must be done carefully, as the internal maxillary artery lies behind the bone where the opening is made. The mucous membrane of the antral roof must then be divided, and the bone forming the floor of the canal, in which the nerve lies, broken away. The nerve is then pulled downward and made tense by means of the attached ligature, and is followed backward across the antrum and into the spheno-maxillary fossa. Long curved scissors will permit the surgeon

[1] See *The Surgical Treatment of Neuralgia of the Fifth Nerve*, by W. Rose, London, 1892.

to divide it behind the ganglion of Meckel, just outside of the foramen rotundum in the cranial base. Illumination by means of a head-mirror is essential in the successive steps of this operation. The peripheral nerve-branches should be torn out of the tissues of the face, as in the previous method.

The incision for the pterygo-maxillary operation is an inverted V, with its apex at a point just behind and below the external angular process of the frontal bone. One branch of the cut extends downward and backward to the tragus; the other, downward and forward upon the cheek. The zygomatic arch is sawed through at each extremity, after small holes have been drilled on both sides of each proposed saw wound to allow a wire suture to be subsequently inserted to hold the bone in position. The next step is to detach the temporal fascia from the upper margin of the zygoma and turn downward the loosened zygoma. The

FIG. 510.



Surgical treatment of neuralgia of the fifth nerve (Rose): *a*, zygomatic arch divided and turned down; *b*, temporal tendon; *c*, superior maxillary nerve and Meckel's ganglion; *d*, infraorbital nerve.

pterygo-maxillary fissure is thus exposed and the ganglion rendered accessible. A head-mirror is necessary to illuminate the deep wound: even then identification of the ganglion may be rather difficult. If it is desired to remove the infraorbital nerve as well as the ganglion, that

nerve is exposed under the orbit in front and the portion between the two incisions drawn out.

The inferior dental and lingual nerves are derived from the third division of the trigeminal nerve, and occasionally demand operation for the relief of neuralgia. The termination of the inferior dental nerve may be excised at the mental foramen by a cut made through the mucous membrane of the mouth if it is thought best to avoid a cutaneous scar. If a cutaneous incision is decided upon, the external wound should be made under the lower border of the lower jaw at the chin and the skin drawn upward so as to expose the mental foramen. The scar is thus put in an inconspicuous place.

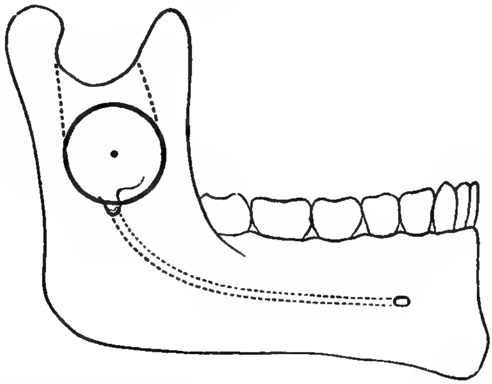
Removal of a considerable portion of the nerve is accomplished by making an incision two inches or more in length just below the lower margin of the jaw, extending a short distance back of the angle. The skin is slipped upward and the muscles detached as far as necessary from the external surface of the jaw. A half-inch trephine is then applied about an inch and a quarter above the angle, so as to cut a button of bone from the entire thickness of the jaw opposite the inferior dental foramen on the inner surface. The nerve crosses this opening from above downward on its way to enter the inferior dental canal. By means of a sharp chisel the channel in which the nerve runs forward can be laid open on the external surface of the bone as far forward as the mental foramen. Several inches of nerve can be exsected by this method of operating. The inferior dental artery will very probably be divided, but pressure or ligation will stop the bleeding.

The nerve may also be satisfactorily exposed by an operation within the mouth, which has the advantage of leaving no external scar. It is necessary to have the mouth kept widely open by a gag placed on the side opposite to that of operation. Incision is made through the mucous membrane along the anterior border of the ascending ramus of the jaw from the last upper molar to the corresponding tooth below. The internal pterygoid muscle is separated from the internal surface of the ascending ramus by means of the finger, which is also used to identify the point of bone situated at the beginning of the inferior dental canal. A sharply-curved hook or aneurysm needle is then to be used to draw the nerve from its bed and make it accessible to stretching and excision. The internal lateral ligament of the lower jaw may be mistaken for the nerve if care is not exercised.

The inferior dental nerve can also be reached for excision by applying a trephine a half inch below the sigmoid notch of the lower jaw and cutting away the bridge of bone between the trephine opening and the notch, so as to deepen the latter. This prolongation downward of the sigmoid notch to the level of the inferior dental canal exposes the inferior dental and also the lingual nerve. This method may also be used when it is desired to excise the third division of the trigeminal nerve where it makes its exit from the oval foramen. The external incision begins about the centre of the zygomatic arch, is carried downward and backward, and then forward, so as to follow the angle and the posterior part of the lower body of the jaw. The cutaneous flap is lifted, and the deep fascia and masseter muscle divided transversely, below and parallel to the duct of the parotid gland. The periosteum is separated from the bone, and a

half-inch trephine applied about half an inch below the bottom of the sigmoid notch. The portion of bone between the lower margin of the notch and the trephine opening is cut away with saw, chisel, or drill. The surgical engine armed with a flat burr would answer well in this operation. Division of the periosteum on the inner side of the bone

Fig. 511.



Side view of lower jaw, showing position of trephine opening in the operation for deepening the sigmoid notch. The dotted lines above the trephine opening indicate the extent of the bridge of bone which needs removal. The inferior dental canal and its anterior and posterior openings are indicated.

allows the inferior dental nerve to be seen. The lingual nerve is situated about half an inch deeper and a little in front of the inferior dental. The nerves should then be cut off close to the oval foramen above, and as far below as they can be reached.

The lingual nerve may be exposed as above detailed or by an intra-oral route. A string is carried through the tongue by a needle, on the side of the middle line toward the nerve to be excised. By it the tongue is drawn out of the mouth and toward the opposite side; this causes the nerve to become prominent as a cord beneath the mucous membrane of the floor of the mouth, between the jaw and the tongue. The mucous membrane is to be clipped away and the nerve raised on a hook and exsected. The nerve may also be found under the mucous membrane close to the jaw beneath the first lower molar tooth. It is stretched or excised in neuralgia and in malignant disease of the tongue.

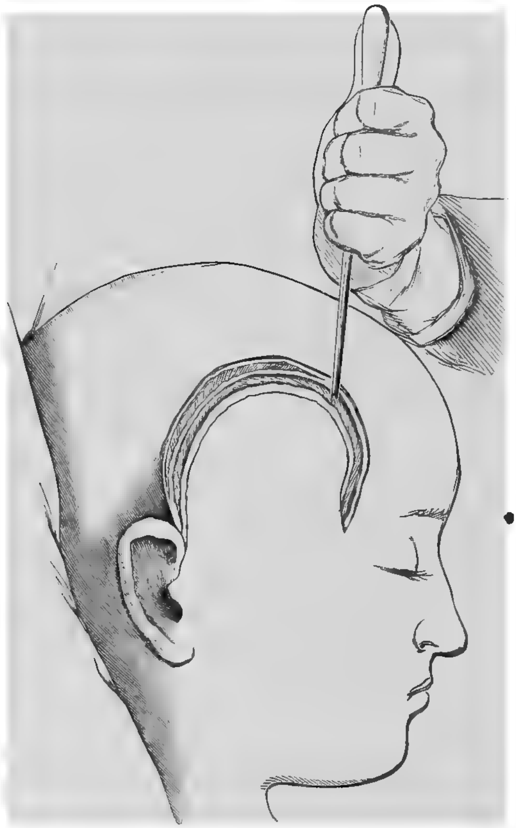
When the neuralgic pain of tic douloureux returns after a period of relief from the peripheral operations just detailed, the surgeon is justified in doing an intracranial operation for removal of the nerves in front of the Gasserian ganglion and the Gasserian ganglion itself. Two routes have been employed for the accomplishment of this object. One enters the cranial cavity by boring through the base near the oval foramen; the other makes an osteoplastic resection in the temporal region, turns down a flap of bone, and separates the dura mater from the base of the skull. The former has been advocated particularly by Rose and Andrews.[1] The latter was suggested by Horsley, but has been more recently advocated by Hartley and Krause. The temporal route is probably less dangerous

[1] *Journal of American Medical Association*, 1891.

than the basal. The operation through the base of the skull is performed by dividing the zygoma in two places, cutting off the coronoid process of the jaw, detaching the masseter and temporal muscles, and applying a trephine of special form to the bone around the oval foramen. A chisel may be used for making the opening through the base of the skull. The Gasserian ganglion so reached is scraped away by a curette and the parts replaced. The ganglion is situated at the apex of the petrous portion of the temporal bone on its anterior aspect, and lies beneath the dura mater with a layer of periosteum between it and the base of the skull. The cavernous sinus is close to the ganglion on its inner side.

In the operation through the temporal region of the skull an omega-shaped incision is made in the temporal fossa, with the top of its curve near the temporal ridge, its anterior extremity near the external angular process of the frontal bone, and its posterior end near the tragus of the

FIG. 512.

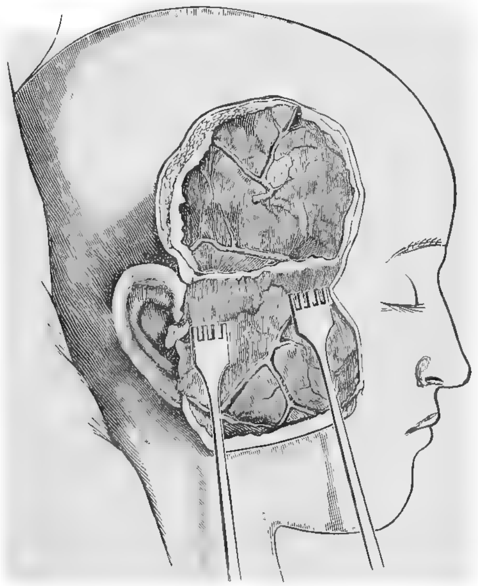


Showing manner of holding the chisel in cutting the groove through the bone (Hartley).

auricle. The soft tissues are cut through to the bone, and a chisel which cuts a triangular groove is employed to divide the bone along the same line. A small chisel ground like an osteotome makes a very good instru-

ment for this purpose. Care must be taken not to drive the chisel through the bone into the brain. This is easily prevented by using the corner of the chisel to divide the bone along the line marked out in the soft parts. This part of the operation may be performed by one of the forms of surgical engine, run by an electro-motor or the operator's foot. An elevator inserted under the edge of the bone serves to pry up the flap, consisting of skin, muscle, periosteum, and bone. Fracture takes place across the base of the omega-like incision just above the zygomatic arch. The soft parts make a sort of hinge which allows the bone to be bent outward. The dura and the middle meningeal artery are exposed. If the artery has run through a canal in the bone, it will be torn and require ligation. The dura and the temporal lobe above it are then carefully lifted from the base of the skull, and held upward and to the other side, so that the three divisions of the trigeminal nerve may be seen. The nerves are then followed backward, and serve as guides to the Gasserian ganglion, which is exposed by dividing the layer of dura covering it. Illumination by the electric light or other head-mirror is necessary for the satisfactory performance of this step of the operation. The cavernous sinus must be carefully avoided. The ganglion is then scraped away, the dura and cerebral convolutions permitted to fall into place, the flap of bone and soft tissues turned upward, and sutures applied to the skin and muscle.

Fig. 513.



Flap elevated and turned down, exposing the dura mater and middle meningeal artery (Hartley).

If hemorrhage is profuse before the ganglion is found, it may become necessary to insert a piece of gauze for the purpose of making pressure, and close the wound. At the end of two or three days the wound is to be reopened and the ganglion sought for and extirpated. It is doubted

by some whether the ganglion has been entirely removed in the cases reported, but the relief of pain has been immediate. All the cases subjected to operation are of comparatively recent date, but several years have elapsed in some of them without recurrence of the torturing pain. Death has occurred in some instances, but the character of the disease justifies the operation. The temporal route, as previously mentioned, is believed to be the safer. Asher reports[1] a case of inflammation of the middle ear occurring in a case of intracranial excision of the second and third divisions, done by Czerny by the temporal route.

Dr. W. T. Taylor has made an elaborate study[2] of the osseous anatomy of the region, and Dr. Keen[3] has tabulated the cases recorded. Dr. Joseph M. Spellissy has added to Keen's table for me some later operations by various surgeons, and gives the following results: Rose's method, 18 recoveries, 3 deaths; Hartley's method, 18 recoveries, 2 deaths; Horsley's method, no recoveries, 1 death; unknown method, 1 recovery, 1 death. In some of these cases the ganglion was only partly removed, or only the intracranial portions of the nerve were excised. Tiffany has recently reported a number of new cases.[4]

The Facial Nerve.

The operative steps required to reach the facial nerve have been detailed in the section on the treatment of Facial or Histrionic Spasm. Exposure of the spinal accessory nerve and that of the posterior branches of the upper cervical nerves have been described in the section treating of Spasmodic Torticollis.

The Cervical Nerves.

The great auricular and the superficial cervical nerves are branches of the cervical plexus, and may be exposed by incision along the posterior edge of the sterno-mastoid muscle. They both make their appearance from behind and turn over the edge of the muscle near its middle in the vicinity of the spinal accessory or tenth cranial nerve. The great auricular takes a forward and upward course; the superficial cervical, one almost directly forward; the spinal accessory trunk lies deeper and runs downward and outward toward the trapezius muscle. The small occipital branch of the cervical plexus may be uncovered by an incision behind the sterno-mastoid, at a point a little below the junction of the upper and middle third of a line drawn from the mastoid process to the collar bone.

The Sympathetic Nerve.

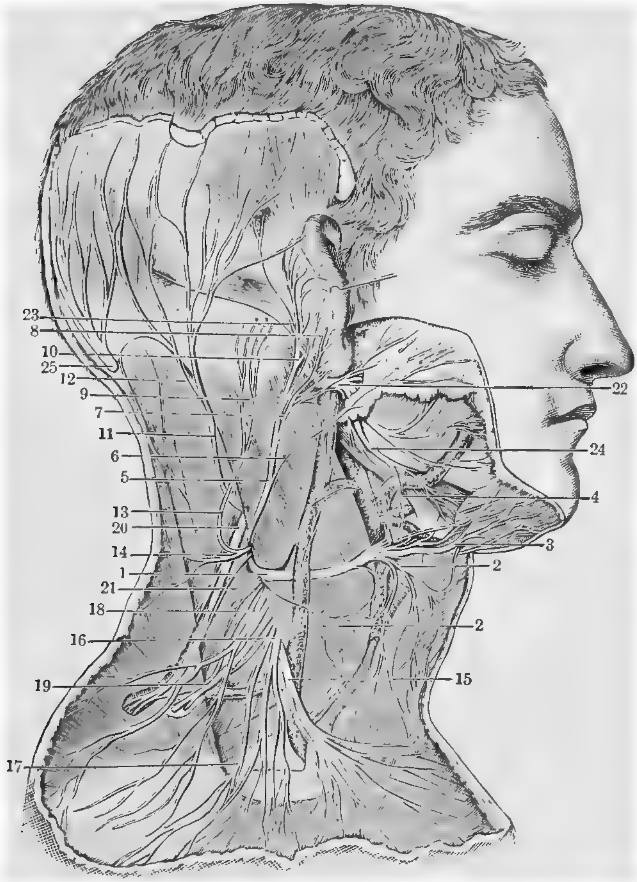
A definitely planned operation for exploring the condition of the superior cervical ganglion of the sympathetic nerve is reported by Alexander B. Johnson.[5] The symptoms pointed to a destructive lesion of the cervical sympathetic nerve. They were paroxysmal pain behind the lobule of the ear, tenderness, dimness of vision in right eye, constant

[1] *Beitrag zur klin. Chir.*, Tübingen, 1894, xi. 701.
[2] *Trans. Philada. County Medical Society*, 1894.
[3] *Ibid.*
[4] *Annals of Surgery*, May, 1895.
[5] *New York Medical Journal*, 1894, i. 557.

lachrymation from that organ, flushing of the right side of face, increase of perspiration on right side of face, ptosis of right eyelid, and contracted right pupil, which did not react to light.

An incision three and a half inches in length was made along the

FIG. 514.



Superficial branches of the cervical plexus: 1, superficialis Colli; 2, 2, its descending branches; 3, its ascending branches; 4, filaments of anastomosis with the facial; 5, auricularis magnus; 6, its parotid branch; 7, its external auricular branch; 8, upper part of the same branch, crossing the fibrous tissue which surrounds the root of the helix and supplying the external surface of the pinna; 9, internal auricular branch; 10, filament of anastomosis between this branch and the posterior auricular of the facial; 11, occipitalis minor; 12, branch of communication with the occipitalis major; 13, accessory occipitalis minor; 14, branches of the integument on the back of the neck: 15, supraclavicular branches, sternal portion; 16, clavicular portion; 17, supra-acromial branches, sternal posterior division; 18, posterior division; 19, branch to trapezius from cervical plexus; 20, branch to trapezius from the spinal accessory and anastomosing with the preceding; 21, branch to the levator anguli scapulæ; 22, trunk of the facial; 23, its posterior auricular branch; 24, its cervical and mental branches (Hirschfeld.).

posterior border of the right sterno-mastoid muscle, beginning just below the mastoid process. The muscle and internal jugular vein were displaced forward, the internal carotid artery lifted, and the superior cervical ganglion of the sympathetic nerve looked for upon the surface of

the greater anterior straight muscle. It was found included in, and adherent to, the sheath of the artery. The adhesions were divided; the ganglion and two inches of the nerve below the ganglion were then dissected loose. The ganglion and sympathetic nerve seemed normal. The wound healed rapidly, and the symptoms disappeared, but recurred at the end of a month and a half.

Excision of this ganglion with two and a half inches of the nervous cord was done by Remak during the removal of a tumor.[1] Brown-Séquard discusses[2] excision of this ganglion in its relation to epilepsy; Bogdanik[3] reports a case of excision of the left middle sympathetic ganglion for epilepsy. The boy had had no repetition of the seizures at the time of the report, which was only three weeks subsequent to the operation.

Nerves of the Trunk.

The only nerves of the trunk at all likely to be subjected to stretching or excision are the intercostals. Any one of these would be reached by an incision along the lower border of the corresponding rib, inward displacement of the pleura, and a search for the nerve in the groove along the inside of the edge of the bone.[4] The intercostal artery would probably require tying.

Nerves of the Upper Extremity.

The brachial plexus is easily found by an incision in the middle of the axilla parallel to the long axis of the humerus. It may be reached in the neck by the cut, above the clavicle and parallel to it, that is adopted for ligation of the subclavian artery. A probably better incision is that parallel to the anterior edge of the trapezius, extending upward from the middle of the clavicle. It should not begin at the clavicle, but half an inch above it, lest the subclavian vessels be injured. Secondary suture of the external cord of the brachial plexus has been done.[5] Maury[6] and Sands have excised portions of the plexus. Abbe has performed with success intradural excision of the roots of the brachial plexus for spastic paralysis, athetoid motion,[7] and pain in the arm of a patient forty years of age. Such intradural operations are proper in intractable cases after more peripheral excisions have proved unavailing.

The median nerve is uncovered by an incision along the inner border of the biceps muscle at its middle. The nerve here crosses the brachial artery obliquely from without inward. The incision is the same as that for tying the artery. Near the wrist an incision along the ulnar side of the tendon of the radial flexor of the wrist will enable the operator to find the nerve under the deep fascia.

There is no objection to making an elliptical flap in exposing nerve-

[1] Sajous' *Annual of the Universal Medical Sciences*, 1889, ii. (B. 4.).
[2] *Arch. de Physiol. norm. et path.*, 1891, iii. 216.
[3] *British Med. Journ.*, March 24, 1894; *Epitome*, p. 46.
[4] *Rev. de Chir.*, Paris, 1889, xi. 923, and *Journ. de Méd. chir. et pharmacol.*, Brux., 1891, xcii. 136.
[5] *Gazz. degli osped.*, Milano, 1892, xiii. 763.
[6] *Amer. Journ. Med. Sciences*, lxxiii. p. 413.
[7] *Annals of Surgery*, Jan., 1895, p. 53.

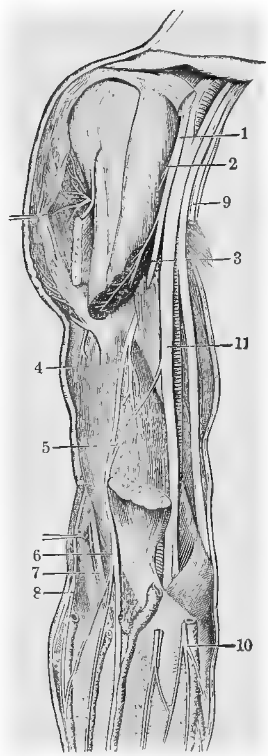
trunks for operation. A flap gives better opportunity for finding the landmarks than does a straight incision.

The incision for reaching the ulnar nerve in the middle of the arm should be similar to that given above for the median nerve, but it should be about half an inch from the margin of the biceps, toward the inside of the arm. This nerve can also be readily found by an incision between the internal condyle of the humerus and the olecranon. To uncover it near the wrist the tissues must be laid open along the radial side of the tendon of the ulnar flexor of the wrist. At this point the nerve is covered by two layers of the deep fascia.

To find the musculo-spiral nerve a line is to be drawn from the tip of the acromion process to the external condyle of the humerus. On this line an incision is to be made with its centre midway between the external condyle and the insertion of the deltoid muscle. In the intermuscular space between the triceps and biceps the nerve will be found lying against the humerus. Its cutaneous branch will probably be seen first running in the same intermuscular space. The edge of the belly of the long supinator will aid in the search for the nerve, which lies between it and the anterior brachial muscle. The supinator should be drawn outward to disclose the nerve.

The radial nerve requires for its exposure an incision on the outer side of the arm about three inches above the wrist. It is here found as it passes from the front of the forearm under the long supinator tendon to reach the back of the wrist and hand.

FIG. 515.



Brachial portion of the musculo-cutaneous, median, and ulnar nerves: 1, musculo-cutaneous nerve; 2, branch to the coraco-brachialis muscle; 3, branch to the biceps muscle; 4, branch to the brachialis anticus; 5, anastomotic filament which it receives from the median nerve; 6, division of the nerve where it crosses the aponeurosis of the arm; 7, musculo-spiral nerve passing between the brachialis anticus and supinator longus muscle; 8, external cutaneous branch of the musculo-spiral nerve; 9, trunk of the internal cutaneous dividing just below its origin, thus giving off an accessory branch; 10, anterior or ulnar branch of this nerve; 11, brachial portion of the median and ulnar nerves (Sappey).

Nerves of the Lower Extremity.

The great sciatic nerve is exposed for stretching just below the inferior edge of the great gluteal muscle between the tuberosity of the ischium and the great trochanter of the femur. A line drawn from a point half an inch nearer the tuberosity of the ischium than the trochanter, downward to the middle of the popliteal space, indicates the course of the nerve. A three- or four-inch incision in this line and beginning just above the gluteo-femoral crease gives access to the nerve in its

most superficial portion. After the lower margin of the great gluteal muscle has been uncovered the biceps muscle will be seen coming from beneath this edge. The gluteal muscle should be drawn upward and the biceps and other hamstring muscles inward. The nerve, which is a very large cord, will then be seen. Flexion of the knee will relax the hamstring muscles and render their displacement easy. There is often a good deal of fat in the subcutaneous tissues, and the external incision required is sometimes a long one. When it is desired to gain access to this nerve in the popliteal space, a vertical incision should be made in the middle line. The surgeon will then come upon the nerve-trunk or the internal popliteal nerve according as the main trunk divides into the external and internal popliteal at a high or low point.

Excision of the great sciatic nerve is seldom undertaken, because of the paralysis thereby produced. The temporary paralysis due to nerve-stretching is not so serious a condition, and neurectasy is therefore frequently done for the cure of sciatic neuralgia.

The internal popliteal nerve is also readily exposed for operation by a vertical incision beginning in the middle of the popliteal space and extending downward toward the junction of the two heads of the gastrocnemius muscle.

The external popliteal nerve, which is smaller than the internal popliteal, lies just inside of the tendon of the biceps muscle at the outer edge of the popliteal space. An incision parallel to this tendon and just back of it will lead to the nerve. The lower half of this incision should be over the fibula. Slight flexion of the knee to relax the parts will enable the surgeon to find the nerve near the insertion of the biceps tendon into the head of the fibula.

The anterior crural nerve makes its appearance upon the front of the thigh immediately below Poupart's ligament, in the hollow between the psoas and iliacus muscles. It is separated from the femoral artery by the belly of the psoas muscle. A vertical incision commencing a little above Poupart's ligament over the groove mentioned will enable the operator to expose the nerve.

The anterior and posterior tibial nerves lie on the fibular side of the corresponding arteries, and are reached by the same incisions as are employed in ligation of these arteries.

The internal saphenous nerve is reached by an incision along the posterior margin of the sartorius muscle opposite the tuberosity of the tibia. The nerve lies posteriorly to the internal saphenous vein.

The musculo-cutaneous nerve will be found emerging from the deep fascia covering the muscles on the outer and anterior aspect of the leg below its middle. An incision a little below the middle of the leg in a line drawn from the front of the head of the fibula to the posterior border of the external malleolus will disclose the nerve as it makes its exit from the deep fascia.

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